ICARUS AND DAEDALUS

By Sir Frederick Leighton, 1830-1889.

SIR FREDERICK LEIGHTON was born at Scarborough, England, in 1830. His father was a doctor, but early recognized his son's bias toward painting and gave him what he considered the best training for his profession. At ten his father started him on a series of grand tours, visiting Rome, Florence, Frankfort, Berlin, Paris, and Brussels. In each of these places he received instructions from the most distinguished masters. He exhibited his first picture (The Procession of Cimabue's Madonna) at the Royal Academy in 1855. This picture was bought by the Queen. After this he studied in Paris four years under Ary Scheffer. He became a Royal Academician in 1869, and on the death of Sir Francis Grant in 1878 he was elected president and was knighted. He was created a baronet in 1886.

Sir Frederick Leighton is a scholar and man of the world as well as an artist. He has gained great distinction in art, both as painter and sculptor. He won the grand medal of honor for sculpture at the Paris Exposition of 1889.

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EDITORS EDITION

EDITOR-IN-CHIEF OLIVER J. THATCHER
DEPARTMENT OF HISTORY UNIVERSITY OF CHICAGO

Author "Europe in the Middle Ages," "A Short History of Mediaeval Europe," "A General History of Europe," "A Sketch of the History of the Apostolic Church."

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VOLUME X.

SOCIAL MOVEMENTS

PROBABLY the most important social movement of the present time springs from a conception of the state as a social organism in opposition to the Adam Smith conception of it as economically merely a conglomeration of individuals. On the latter theory each individual should be left to himself, competition should be uncontrolled, the government should keep out of economic affairs. On the former basis, the state is an organism which should control all its parts for the good of the whole.

Such attempts by government to control trade are not new, but the object would seldom be "for the good of the whole" except where was acknowledged the sovereignty of the people. It is interesting to glance back over such attempts to control industry made by governments, and at the same time compare the efforts made by individuals or classes to control it for their own benefit.

In Greece, Sparta by its peculiar laws made itself an agricultural aristocracy with the work done by serfs. Trade was practically annihilated. In Athens all were free to come and trade. The government, however, fixed a maximum price on olives, grain, barley meal, bread; saw that the food was kept pure, and the measures correct; and prevented a "corner" on grain by compelling two-thirds of that imported to be put on the market. Here, too, as in Sparta, the traders were foreigners and not a respected class. The manual work was done by slaves.

In Italy the land fell into the hands of large slave-holders, who used it for grazing purposes. The government sold imported grain for less than the small Italian farmers could raise it, and thus ruined the

small farmer for the benefit of the population at Rome. The Roman senator was forbidden from entering into any speculative trade venture, *e. g.*, commerce, or the farming of the revenue; but this law was often avoided by joining an association. Almost all large businesses at Rome were carried on by incorporated associations. A man was advised to send out fifty ships with forty-nine other merchants rather than to send out one on his own account. It gave him the benefit of the law of averages,—acted as now does insurance, which was unknown in those days.

Hand labor suffered in social status because of the proximity of slave labor. But this seems to have been lessened to some extent by the existence of trade corporations. Numa is fabled to have divided workmen into nine classes, each of which became a society. Such associations later became regular corporations, and exerted considerable influence on the economics of the time. The membership seems both in the time of the republic and empire to have been voluntary, but they seem to have included practically all free craftsmen in the large cities.

Taken altogether the system of the empire was decidedly paternal. Mines and roads of communication were owned by the government, and the emperor paid very close attention to affairs which we should now consider strictly municipal.

During the middle ages, practically all trades were under control of trade guilds. We read of a weavers' and fullers' guild in England as early as 1130. No one was permitted by the king to follow an occupation unless a member of the guild, and an apprenticeship, usually of seven years, was necessary before a man could be admitted to a guild. Merchant guilds also existed early, but liberty in buying and selling was in general given to all in England in 1335. From the twelfth to the eighteenth century the guilds practically regulated industry, subject to the control of the king. In the eighteenth century the guilds did not keep pace with the growth of the great industries, and were fiercely attacked by the *laissez-faire* school of economists. Their influence waned and the laws in their favor were left uninforced. The law compelling apprenticeship was abolished in 1814, and all trade privileges of the guilds taken away. But not long after this trade unions began to be developed to take their place.

Even before the time of the Tudors it was the custom of the king to give the monopoly of dealing in a certain article to some favorite as a reward. In the time of Elizabeth these monopolies included such

things as salt, currants, iron, playing cards, carriage of leather, ashes, coals, bottles, vinegar, etc. The growth of the system roused great discontent, a fierce struggle was waged against it in Parliament in 1601, and Elizabeth promised to revoke the patents. The matter was again brought to a crisis under James I. by the extortion of the licensers of inns, and the whole power was taken from the Crown except in the case of patent rights. During the next century Parliament gave exclusive power to trade in some certain district to a particular company formed for exploitation or colonization, as, for example, the East India Company or the many American companies, but the economic ideas of Adam Smith at the end of the eighteenth century overthrew even this policy, and since then the government has confined exclusive privileges given to private individuals to patents or copyrights.

Nineteenth century socialism came in with the century. Fourier in 1808 published his theoretical pantheistic view of the world and maintained that all civilization had been but putting the world farther from its Creator. His phantasies passed without effect, but in 1817 Owen laid a scheme for a socialistic community before the House of Commons committee on the poor law. A number of such social communities sprang up, among them the famous Brook Farm in the United States, but practically all were short lived.

In 1831 the workingmen of Lyons, France, rose in revolt under a banner inscribed "Live working or die fighting." A like movement was the Chartist revolts by workingmen in the thirties, for although their demands were political, yet the ground of the discontent was primarily economic. All of these movements had their rise and fall leaving little permanent results except the establishment of trade unions, but showing an important undercurrent in society, when Karl Marx gave a scientific expression to the movement in Germany.

Karl Marx (1818-1883) was of Jewish descent. He was a lawyer, but gave up his profession for social studies. Between 1843 and 1845 he was in Paris, and published several articles on socialism. At this time, also, he met his lifelong friend, Friedrich Engels. In 1845 he was expelled from Paris and settled in Brussels. A society of socialists had been organized as the Communist League and at a congress held in 1847, Marx and Engels gave to the world the famous "Manifesto of the Communist Party" included below.

In 1867 Marx published the first volume of his great work "Das Kapital." The basis of his system is Locke's idea that the source of

value and property is labor. Hence he argues that all surplus product over the necessary subsistence of the laborer belongs to the laborer, but he declares that as a fact this goes to the capitalist.

This theory found an important result in the formation of The International, a league of workmen of the continent which lasted from 1864 to 1872, and in the gradual growth of trade unions.

One of the first organizers of modern trade unions in Germany was Ferdinand Lassalle, but at his death in 1864 his general workingmen's union numbered only 4,610 members.

In a great congress at Eisenach in 1869 representatives of the many outside unions founded the social democratic workingmen's party and a combination was made with the Lassalle party in 1875. The two together by this time numbered 25,000 members. Since this time the socialists have been an important power in German politics.

In England from 1799 to 1824 there had grown up a mass of laws against restriction of trade, as a reaction against the mercantile theory of the eighteenth century. Until 1824 it was a crime to belong to a union. Such restrictions were partly removed in that year and more fully in 1871.

In the United States there were many local unions early in the century, but the first union including all the main trades of a city seems to have been in 1833 in New York. In 1861 a number of trades had a national organization. After the war organization was again begun and spread rapidly until the panic of '73. From 1877 to 1893 the labor unions seem to have had a rapid growth and the decrease in the panic of '93 was only about 12 per cent., not as great as during previous depressions. To-day practically all general trades are well organized, especially in cities of some size.

The necessity of a city water supply, the general spread of lighting by gas, the invention of the railroad in 1814, of the telegraph in 1835, of the telephone in 1878, of the incandescent electric light in 1879, and the introduction of electric street railways all created a class of industries which have been called "natural monopolies." They are all public utilities, and only one is essential in a given field; that is, each plays an important part in present day civilization, has in fact, become a public necessity, and as each is practically unlimited in possible capacity, it is vastly more economical to have one industry than two or more of the same kind in the same field.

Since 1882 another class of partial monopolies has sprung up. In 1882 the Standard Oil Company was organized, which was able to control about 85 per cent. of the total output of refined oil in the United States. Since then a vast number of such combinations have been formed, all aiming to control the most of the output and the prices in their lines. Vast capital, enabling them to wait for returns, better freight rates, which their greater volume of business has enabled them to procure, the cutting off of routine expenses and the expense of competitive selling, have all given them an advantage over the small competitor.

These are real economic advantages. The evils result chiefly from an ability to charge too high where there is a virtual monopoly; special rates from public utilities such as railroads; and undue influence in city councils and other legislative bodies.

The question of the control of such monopolies is one that is sure to be of the greatest importance in the near future. It involves a direct opposition between the idea of government as made up of individuals with the consequent *laissez-faire* principles of economy, and the idea of it as a social organism where the whole should supervise all its parts. Most of our ideas of government ownership or control come, though bereft of its most radical features, from the socialism of Marx and Engels. This in a far less extreme form is also the basis of the socialist party of Germany—the strongest single party in numbers in the empire —and of the state socialism represented by the Fabian Society, for example, in England.

KARL MARX

Karl Marx was born of Jewish parents at Treves, in the province of the Rhine, May 5, 1818. He studied at Bonn and Berlin, and began the practice of law, then gave it up, and became editor of a radical newspaper that was suppressed because of its attacks on the Prussian government.

He moved to Paris, but was expelled in 1845, and went to Brussels, where he founded a German workingman's association, and issued (with Engels) his famous "Manifesto" given below.

He again became editor of the *Rheinische Zeitung* at Cologne, but it was again suppressed, and he went to England, where were his headquarters for the rest of his life.

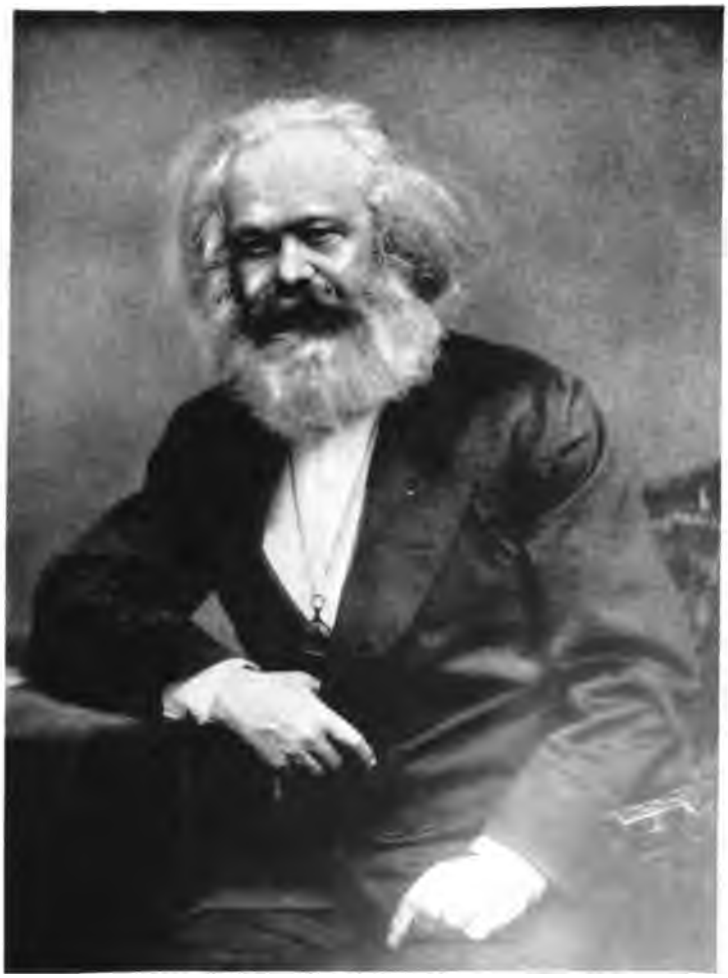
The International Workingmen's Association was founded in 1864. The first volume of *Das Kapital* was issued in 1867. Marx starts in with Locke's idea that the basis of property is labor, and works out a theory that in the evolution of society, the employing class has come to appropriate the surplus earnings of labor. This, with his consideration of society as an evolution, are the two most important and influential ideas of the book.

The "Manifesto" was much more radical and heated than this later exposition of his ideas, but he believes in the inevitable assumption by the laboring class of the means of production.

His theories are a part of almost all socialistic writings, and, without his radical and unnecessary features, the idea that society is an organism which should control what concerns all for the good of all is playing a prominent part in all present day social thought.

Marx died in London, March 14, 1883.

KARL MARX



MANIFESTO OF THE COMMUNIST PARTY

By Karl Marx and Friedrich Engels

A specter is haunting Europe—the specter of Communism. All the powers of old Europe have entered into a holy alliance to exorcise this specter; Pope and Czar, Metternich and Guizot, French radicals and German police spies.

Where is the party in opposition that has not been decried as communistic by its opponents in power? Where the opposition that has not hurled back the branding reproach of Communism, against the more advanced opposition parties, as well as against its reactionary adversaries?

Two things result from this fact.

I. Communism is already acknowledged by all European powers to be in itself a power.

II. It is high time that Communists should openly, in the face of the whole world, publish their views, their aims, their tendencies, and meet this nursery tale of the Specter of Communism with a manifesto of the party itself.

To this end the Communists of various nationalities have assembled in London, and sketched the following manifesto to be published in the English, French, German, Italian, Flemish and Danish languages.

I.

Bourgeois and Proletarians

The history of all hitherto existing society is the history of class struggles.

Freeman and slave, patrician and plebeian, lord and serf, guild-master and journeyman, in a word, oppressor and oppressed, stood in constant opposition to one another, carried on an uninterrupted, now hidden, now open fight, that each time ended either in revolutionary reconstitution of society at large, or in the common ruin of the contending classes.

In the earlier epochs of history we find almost everywhere a complicated arrangement of society into various orders, a manifold grada-

tion of social rank. In ancient Rome we have patricians, knights, plebeians, slaves; in the middle ages, feudal lords, vassals, guild-masters, journeymen, apprentices, serfs; in almost all of these classes, again, subordinate gradations.

The modern bourgeois society that has sprouted from the ruins of feudal society has not done away with class antagonisms. It has but established new classes, new conditions of oppression, new forms of struggle in place of the old ones.

Our epoch, the epoch of the bourgeois, possesses, however, this distinctive feature: it has simplified the class antagonisms. Society as a whole is more and more splitting up into two great hostile camps, into two great classes directly facing each other: Bourgeoisie and Proletariat.

From the serfs of the middle ages sprang the chartered burghers of the earliest towns. From these burgesses the first elements of the bourgeoisie were developed.

The discovery of America, the rounding of the Cape, opened up fresh ground for the rising bourgeoisie. The East Indian and Chinese markets, the colonization of America, trade with the colonies, the increase in the means of exchange and in commodities generally, gave to commerce, to navigation, to industry, an impulse never before known, and thereby, to the revolutionary element in the tottering feudal society, a rapid development.

The feudal system of industry, under which industrial production was monopolized by close guilds, now no longer sufficed for the growing wants of the new markets. The manufacturing system took its place. The guild masters were pushed on one side by the manufacturing middle class; division of labor between the different corporate guilds vanished in the face of division of labor in each single workshop.

Meantime the markets kept ever growing, the demand ever rising. Even manufacture no longer sufficed. Thereupon steam and machinery revolutionized industrial production. The place of manufacture was taken by the giant, Modern Industry, the place of the industrial middle class, by industrial millionaires, the leaders of the whole industrial armies, the modern bourgeois.

Modern industry has established the world's market, for which the discovery of America paved the way. The market has given an immense development to commerce, to navigation, to communication by land. This development has, in its turn, reacted on the extension of industry; and in proportion as industry, commerce, navigation and rail-

ways extended, in the same proportion the bourgeoisie developed, increased its capital, and pushed into the background every class handed down from the middle ages.

We see, therefore, how the modern bourgeoisie is itself the product of a long course of development, of a series of revolutions in the modes of production and of exchange.

Each step in the development of the bourgeoisie was accompanied by a corresponding political advance of that class. An oppressed class under the sway of the feudal nobility, an armed and self-governing association in the mediæval commune, here independent urban republic (as in Italy and Germany), there taxable "third estate" of the monarchy (as in France), afterwards, in the period of manufacture proper, serving either the semi-feudal or the absolute monarchy as a counterpoise against the nobility, and, in fact, corner-stone of the great monarchies in general, the bourgeoisie has at last, since the establishment of Modern Industry and of the world's market, conquered for itself, in the modern representative State, exclusive political sway. The executive of the modern State is but a committee for managing the common affairs of the whole bourgeoisie.

The bourgeoisie, historically, has played a most revolutionary part.

The bourgeoisie, wherever it has got the upper hand, has put an end to all feudal, patriarchal, idyllic relations. It has pitilessly torn asunder the motley feudal ties that bound man to his "natural superiors," and has left remaining no other nexus between man and man than naked self-interest, callous "cash payment." It has drowned the most heavenly ecstacies of religious fervor, of chivalrous enthusiasm, of philistine sentimentalism, in the icy water of egotistical calculation. It has resolved personal worth into exchange value, and in place of the numberless indefeasible chartered freedoms, has set up that single, unconscionable freedom—Free Trade. In one word, for exploitation, veiled by religious and political illusions, it has substituted naked, shameless, direct, brutal exploitation.

The bourgeoisie has stripped of its halo every occupation hitherto honored and looked up to with reverent awe. It has converted the physician, the lawyer, the priest, the poet, the man of science, into its paid wage laborers.

The bourgeoisie has torn away from the family its sentimental veil, and has reduced the family relation to a mere money relation.

The bourgeoisie has disclosed how it came to pass that the brutal

display of vigor in the middle ages, which Reactionists so much admire, found its fitting complement in the most slothful indolence. It has been the first to show what man's activity can bring about. It has accomplished wonders far surpassing Egyptian pyramids, Roman aqueducts, and Gothic cathedrals; it has conducted expeditions that put in the shade all former exoduses of nations and crusades.

The bourgeoisie cannot exist without constantly revolutionizing the instruments of production, and thereby the relations of production, and with them the whole relations of society. Conservation of the old modes of production in unaltered forms was, on the contrary, the first condition of existence for all earlier industrial classes. Constant revolutionizing of production, uninterrupted disturbance of all social conditions, everlasting uncertainty and agitation, distinguish the bourgeois epoch from all earlier ones. All fixed, fast-frozen relations, with their train of ancient and venerable prejudices and opinions, are swept away; all new-formed ones become antiquated before they can ossify. All that is solid melts into air, all that is holy is profaned, and man is at last compelled to face with sober senses his real conditions of life and his relations with his kind.

The need of a constantly expanding market for its products chases the bourgeoisie over the whole surface of the globe. It must nestle everywhere, settle everywhere, establish connections everywhere.

The bourgeoisie has through its exploitation of the world's market given a cosmopolitan character to production and consumption in every country. To the great chagrin of Reactionists, it has drawn from under the feet of industry the national ground on which it stood. All old-established national industries have been destroyed or are daily being destroyed. They are dislodged by new industries, whose introduction becomes a life and death question for all civilized nations, by industries that no longer work up indigenous raw material, but raw material drawn from the remotest zones, industries whose products are consumed, not only at home, but in every quarter of the globe. In place of the old wants, satisfied by the productions of the country, we find new wants, requiring for their satisfaction the products of distant lands and climes. In place of the old local and national seclusion and self-sufficiency, we have intercourse in every direction, universal inter-dependence of nations. And as in material, so also in intellectual production. The intellectual creations of individual nations become common property. National one-sidedness and narrow-mindedness become more and

more impossible, and from the numerous national and local literatures, there arises a world literature.

The bourgeoisie, by the rapid improvement of all instruments of production, by the immensely facilitated means of communication, draws all, even the most barbarian, nations into civilization. The cheap prices of its commodities are the heavy artillery with which it batters down all Chinese walls, with which it forces the barbarians' intensely obstinate hatred of foreigners to capitulate. It compels all nations, on pain of extinction, to adopt the bourgeois mode of production; it compels them to introduce what it calls civilization into their midst, *i. e.*, to become bourgeois themselves. In one word, it creates a world after its own image.

The bourgeoisie has subjected the country to the rule of the towns. It has created enormous cities, has greatly increased the urban population as compared with the rural, and has thus rescued a considerable part of the population from the idiocy of rural life. Just as it has made the country dependent on the towns, so has it made barbarian and semi-barbarian countries dependent on the civilized ones, nations of peasants on nations of bourgeois, the East on the West.

The bourgeoisie keeps more and more doing away with the scattered state of the population, of the means of production, and of property. It has agglomerated population, centralized means of production, and has concentrated property in a few hands. The necessary consequence of this was political centralization. Independent, or but loosely connected provinces, with separate interests, laws, governments and systems of taxation, became lumped together into one nation, with one government, one code of laws, one national class interest, one frontier, and one customs tariff.

The bourgeoisie, during its rule of scarce one hundred years, has created more massive and more colossal productive forces than have all preceding generations together. Subjection of Nature's forces to man, machinery, application of chemistry to industry and agriculture, steam navigation, railways, electric telegraphs, clearing of whole continents for cultivation, canalization of rivers, whole populations conjured out of the ground—what earlier century had even a presentiment that such productive forces slumbered in the lap of social labor?

We see then: the means of production and of exchange on whose foundation the bourgeoisie built itself up, were generated in feudal society. At a certain stage in the development of these means of pro-

duction and of exchange, the conditions under which feudal society produced and exchanged, the feudal organization of agriculture and manufacturing industry, in one word, the feudal relations of property, became no longer compatible with the already developed productive forces; they became so many fetters. They had to be burst asunder.

Into their place stepped free competition, accompanied by a social and political constitution adapted to it, and by the economical and political sway of the bourgeois class.

A similar movement is going on before our own eyes. Modern bourgeois society with its relations of production, of exchange, and of property, a society that has conjured up such gigantic means of production and of exchange, is like the sorcerer, who is no longer able to control the powers of the nether world whom he has called up by his spells. For many a decade past the history of industry and commerce is but the history of the revolt of modern productive forces against modern conditions of production, against the property relations that are the conditions for the existence of the bourgeoisie and of its rule. It is enough to mention the commercial crises that by their periodical return put on its trial, each time more threateningly, the existence of the bourgeois society. In these crises a great part not only of the existing products, but also of the previously created productive forces, is periodically destroyed. In these crises there breaks out an epidemic that, in all earlier epochs, would have seemed an absurdity—the epidemic of overproduction. Society suddenly finds itself put back into a state of momentary barbarism; it appears as if a famine, a universal war of devastation had cut off the supply of every means of subsistence; industry and commerce seem to be destroyed; and why? because there is too much civilization, too much means of subsistence, too much industry, too much commerce. The productive forces at the disposal of society no longer tend to further the development of the conditions of bourgeois property; on the contrary, they have become too powerful for these conditions, by which they are fettered, and so soon as they overcome these fetters, they bring disorder into the whole of bourgeois society, endanger the existence of bourgeois property. The conditions of bourgeois society are too narrow to comprise the wealth created by them. And how does the bourgeoisie get over these crises? On the one hand, by enforced destruction of a mass of productive forces; on the other, by the conquest of new markets, and by the more thorough exploitation of the old ones. That is to say, by paving the way for more

extensive and more destructive crises, and by diminishing the means whereby crises are prevented.

The weapons with which the bourgeoisie felled feudalism to the ground are now turned against the bourgeoisie itself.

But not only has the bourgeoisie forged the weapons that bring death to itself; it has also called into existence the men who are to wield those weapons—the modern working class—the proletarians.

In proportion as the bourgeoisie, *i. e.,* capital, is developed, in the same proportion is the proletariat, the modern working class, developed; a class of laborers who live only so long as they find work, and who find work only so long as their labor increases capital,—These laborers, who must sell themselves piecemeal, are a commodity. like every other article of commerce, and are consequently exposed to all the vicissitudes of competition, to all the fluctuations of the market.

Owing to the extensive use of machinery and to division of labor, the work of the proletarians has lost all individual character, and, consequently, all charm for the workman. He becomes an appendage of the machine, and it is only the most simple, most monotonous, and most easily acquired knack, that is required of him. Hence, the cost of production of a workman is restricted almost entirely to the means of subsistence that he requires for his maintenance, and for the propagation of his race. But the price of a commodity, and therefore also of labor, is equal to its cost of production. In proportion, therefore, as the repulsiveness of the work increases, the wage decreases. Nay, more, in proportion as the use of machinery and division of labor increases, in the same proportion the burden of toil also increases, whether by prolongation of the working hours, by increase of the work exacted in a given time, or by increased speed of the machinery, etc.

Modern industry has converted the little workshop of the patriarchal master into the great factory of the industrial capitalist. Masses of laborers, crowded into the factory, are organized like soldiers. As privates of the industrial army they are placed under the command of a perfect hierarchy of officers and sergeants. Not only are they slaves of the bourgeois class, and of the bourgeois State, they are daily and hourly enslaved by the machine, by the overlooker, and, above all, by the individual bourgeois manufacturer himself. The more openly this despotism proclaims gain to be its end and aim, the more petty, the more hateful and the more embittering it is.

The less skill and exertion of strength is implied in manual labor,

in other words, the more modern industry becomes developed, the more is the labor of men superseded by that of women. Differences of age and sex have no longer any distinctive social validity for the working class. All are instruments of labor, more or less expensive to use, according to age and sex.

No sooner is the exploitation of the laborer by the manufacturer so far at an end that he receives his wages in cash, than he is set upon by the other portions of the bourgeoisie, the landlord, the shopkeeper, the pawnbroker, etc.

The lower strata of the middle class—the small tradespeople, shopkeepers, and retired tradesmen generally, the handicraftsmen and peasants—all these sink gradually into the proletariat, partly because their diminutive capital does not suffice for the scale on which modern industry is carried on, and is swamped in the competition with the large capitalists, partly because their specialized skill is rendered worthless by new methods of production. Thus the proletariat is recruited from all classes of the population.

The proletariat goes through various stages of development. With its birth begins its struggle with the bourgeoisie. At first the contest is carried on by individual laborers, then by the workpeople of a factory, then by the operatives of one trade, in one locality, against the individual bourgeois who directly exploits them. They direct their attacks not against the bourgeois conditions of production, but against the instruments of production themselves; they destroy imported wares that compete with their labor, they smash to pieces machinery, they set factories ablaze, they seek to restore by force the vanished status of the workman of the middle ages.

At this stage the laborers still form an incoherent mass scattered over the whole country, and broken up by their mutual competition. If anywhere they unite to form more compact bodies, this is not yet the consequence of their own active union, but of the union of the bourgeoisie, which class, in order to attain its own political ends, is compelled to set the whole proletariat in motion, and is moreover yet, for a time, able to do so. At this stage, therefore, the proletarians do not fight their enemies, but the enemies of their enemies, the remnants of absolute monarchy, the land owners, the non-industrial bourgeois, the petty bourgeoisie. Thus the whole historical movement is concentrated in the hands of the bourgeoisie; every victory so obtained is a victory for the bourgeoisie.

But with the development of industry the proletariat not only increases in number; it becomes concentrated in greater masses, its strength grows and it feels that strength more. The various interests and conditions of life within the ranks of the proletariat are more and more equalized, in proportion as machinery obliterates all distinctions of labor, and nearly everywhere reduces wages to the same low level. The growing competition among the bourgeois, and the resulting commercial crises, make the wages of the workers ever more fluctuating. The unceasing improvement of machinery, ever more rapidly developing, makes their livelihood more and more precarious; the collisions between individual workmen and individual bourgeois take more and more the character of collisions between two classes. Thereupon the workers begin to form combinations (Trades' Unions) against the bourgeois; they club together in order to keep up the rate of wages; they found permanent associations in order to make provision beforehand for these occasional revolts. Here and there the contest breaks out into riots.

Now and then the workers are victorious, but only for a time. The real fruit of their battles lies not in the immediate result, but in the ever improved means of communication that are created in modern industry and that place the workers of different localities in contact with one another. It was just this contact that was needed to centralize the numerous local struggles, all of the same character, into one national struggle between classes. But every class struggle is a political struggle. And that union, to attain which the burghers of the middle ages, with their miserable highways, required centuries, the modern proletarians, thanks to railways, achieve in a few years.

This organization of the proletarians into a class, and consequently into a political party, is continually being upset again by the competition between the workers themselves. But it ever rises up again; stronger, firmer, mightier. It compels legislative recognition of particular interests of the workers, by taking advantage of the divisions among the bourgeoisie itself. Thus the ten-hours' bill in England was carried.

Altogether, collisions between the classes of the old society further, in many ways, the course of development of the proletariat. The bourgeoisie finds itself involved in a constant battle. At first with the aristocracy; later on, with those portions of the bourgeoisie itself whose interests have become antagonistic to the progress of industry; at all times with the bourgeoisie of foreign countries. In all these countries it sees itself compelled to appeal to the proletariat, to ask for its help, and

thus to drag it into the political arena. The bourgeoisie itself, therefore, supplies the proletariat with weapons for fighting the bourgeoisie.

Further, as we have already seen, entire sections of the ruling classes are, by the advance of industry, precipitated into the proletariat, or are at least threatened in their conditions of existence. These also supply the proletariat with fresh elements of enlightenment and progress.

Finally, in times when the class struggle nears the decisive hour, the process of dissolution going on within the ruling class, in fact within the whole range of old society, assumes such a violent, glaring character, that a small section of the ruling class cuts itself adrift and joins the revolutionary class, the class that holds the future in its hands. Just as, therefore, at an earlier period, a section of the nobility went over to the bourgeoisie, so now a portion of the bourgeoisie goes over to the proletariat, and in particular, a portion of the bourgeois ideologists, who have raised themselves to the level of comprehending theoretically the historical movement as a whole.

Of all the classes that stand face to face with the bourgeoisie to-day, the proletariat alone is a really revolutionary class. The other classes decay and finally disappear in the face of modern industry; the proletariat is its special and essential product.

The lower middle class, the small manufacturer, the shopkeeper, the artisan, the peasant, all these fight against the bourgeoisie to save from extinction their existence as fractions of the middle class. They are therefore not revolutionary, but conservative. Nay, more, they are reactionary, for they try to roll back the wheel of history. If by chance they are revolutionary, they are so only in view of their impending transfer into the proletariat; they thus defend not their present, but their future interests, they desert their own standpoint to place themselves at that of the proletariat.

The "dangerous class," the social scum, that passively rotting class thrown off by the lowest layers of old society, may here and there be swept into the movement by a proletarian revolution; its conditions of life, however, prepare it far more for the part of a bribed tool of reactionary intrigue.

In the conditions of the proletariat, those of old society at large are already virtually swamped. The proletarian is without property; his relation to his wife and children has no longer anything in common with the bourgeois family relations; modern industrial labor, modern

subjection to capital, the same in England as in France, in America as in Germany, has stripped him of every trace of national character. Law, morality, religion are to him so many bourgeois prejudices, behind which lurk in ambush just as many bourgeois interests.

All the preceding classes that got the upper hand sought to fortify their already acquired status by subjecting society at large to their conditions of appropriation. The proletarians cannot become masters of the productive forces of society, except by abolishing their own previous mode of appropriation, and thereby also every other previous mode of appropriation. They have nothing of their own to secure and to fortify; their mission is to destroy all previous securities for, and insurances of, individual property.

All previous historical movements were movements of minorities, or in the interest of minorities. The proletarian movement is the self-conscious, independent movement of the immense majority, in the interest of the immense majority. The proletariat, the lowest stratum of our present society, cannot stir, cannot raise itself up, without the whole super-incumbent strata of official society being sprung into the air.

Though not in substance, yet in form, the struggle of the proletariat with the bourgeoisie is at first a national struggle. The proletariat of each country must, of course, first of all settle matters with its own bourgeoisie.

In depicting the most general phases of the development of the proletariat, we traced the more or less veiled civil war, raging within existing society, up to the point where that war breaks out into open revolution, and where the violent overthrow of the bourgeoisie lays the foundation for the sway of the proletariat.

Hitherto every form of society has been based, as we have already seen, on the antagonism of oppressing and oppressed classes. But in order to oppress a class certain conditions must be assured to it, under which it can at least continue its slavish existence. The serf, in the period of serfdom, raised himself to membership in the Commune, just as the petty bourgeois, under the yoke of feudal absolutism, managed to develop into a bourgeois. The modern laborer, on the contrary, instead of rising with the progress of industry, sinks deeper and deeper below the conditions of existence of his own class. He becomes a pauper, and pauperism develops more rapidly than population and wealth. And here it becomes evident that the bourgeoisie is unfit any longer to be the ruling class in society and to impose its conditions of

existence upon society as an overriding law. It is unfit to rule because it is incompetent to assure an existence to its slave within his slavery, because it cannot help letting him sink into such a state that it has to feed him instead of being fed by him. Society can no longer live under this bourgeoisie; in other words, its existence is no longer compatible with society.

The essential condition for the existence, and for the sway of the bourgeois class, is the formation and augmentation of capital; the condition for capital is wage-labor. Wage-labor rests exclusively on competition between the laborers. The advance of industry, whose involuntary promoter is the bourgeoisie, replaces the isolation of the laborers, due to competition, by their revolutionary combination, due to association. The development of modern industry, therefore, cuts from under its feet the very foundation on which the bourgeoisie produces and appropriates products. What the bourgeoisie therefore produces, above all, are its own grave diggers. Its fall and the victory of the proletariat are equally inevitable.

II.

Proletarians and Communists

In what relation do the Communists stand to the proletarians as a whole?

The Communists do not form a separate party opposed to other working class parties.

They have no interests separate and apart from those of the proletariat as a whole.

They do not set up any sectarian principles of their own by which to shape and mould the proletarian movement.

The Communists are distinguished from the other working class parties by this only: 1. In the national struggles of the proletarians of the different countries, they point out and bring to the front the common interests of the entire proletariat, independently of all nationality. 2. In the various stages of development which the struggle of the working class against the bourgeoisie has to pass through, they always and everywhere represent the interests of the movement as a whole.

The Communists, therefore, are on the one hand, practically the most advanced and resolute section of the working class parties of

every country, that section which pushes forward all others; on the other hand, theoretically they have over the great mass of the proletariat the advantage of clearly understanding the line of march, the conditions, and the ultimate general results of the proletarian movement.

The immediate aim of the Communists is the same as that of all the other proletarian parties: formation of the proletariat into a class, overthrow of the bourgeois supremacy, conquest of political power by the proletariat.

The theoretical conclusions of the Communists are in no way based on ideas or principles that have been invented, or discovered, by this or that would-be universal reformer.

They merely express, in general terms, actual relations springing from an existing class struggle, from a historical movement going on under our very eyes. The abolition of existing property relations is not at all a distinctive feature of Communism.

All property relations in the past have continually been subject to historical change, consequent upon the change in historical conditions.

The French revolution, for example, abolished feudal property in favor of bourgeois property.

The distinguishing feature of Communism is not the abolition of property generally, but the abolition of bourgeois property. But modern bourgeois private property is the final and most complete expression of the system of producing and appropriating products, that is, based on class antagonisms, on the exploitation of the many by the few.

In this sense the theory of the Communists may be summed up in the single sentence: Abolition of private property.

We Communists have been reproached with the desire of abolishing the right of personally acquiring property as the fruit of a man's own labor, which property is alleged to be the groundwork of all personal freedom, activity and independence.

Hard-won, self-acquired, self-earned property! Do you mean the property of the petty artisan and of the small peasant, a form of property that preceded the bourgeois form? There is no need to abolish that; the development of industry has to a great extent already destroyed it, and is still destroying it daily.

Or do you mean modern bourgeois private property?

But does wage labor create any property for the laborer? Not a bit. It creates capital, *i. e.*, that kind of property which exploits wage-labor,

and which cannot increase except on condition of begetting a new supply of wage-labor for fresh exploitation. Property in its present form is based on the antagonism of capital and wage-labor. Let us examine both sides of this antagonism.

To be a capitalist, is to have not only a purely personal, but a social status in production. Capital is a collective product, and only by the united action of many members, nay, in the last resort, only by the united action of all members of society, can it be set in motion.

Capital is therefore not a personal, it is a social power.

When, therefore, capital is converted into common property, into the property of all members of society, personal property is not thereby transformed into social property. It is only the social character of the property that is changed. It loses its class character.

Let us now take wage-labor.

The average price of wage-labor is the minimum wage, *i. e.*, that quantum of the means of subsistence, which is absolutely requisite to keep the laborer in bare existence as a laborer. What, therefore, the wage-laborer appropriates by means of his labor, merely suffices to prolong and reproduce a bare existence. We by no means intend to abolish this personal appropriation of the products of labor, an appropriation that is made for the maintenance and reproduction of human life, and that leaves no surplus wherewith to command the labor of others. All that we want to do away with is the miserable character of this appropriation, under which the laborer lives merely to increase capital, and is allowed to live only in so far as the interest of the ruling class requires it.

In bourgeois society living labor is but a means to increase accumulated labor. In Communist society accumulated labor is but a means to widen, to enrich, to promote the existence of the laborer.

In bourgeois society, therefore, the past dominates the present; in Communist society the present dominates the past. In bourgeois society capital is independent and has individuality, while the living person is dependent and has no individuality.

And the abolition of this state of things is called by the bourgeois: abolition of individuality and freedom! And rightly so. The abolition of bourgeois individuality, bourgeois independence, and bourgeois freedom is undoubtedly aimed at.

By freedom is meant, under the present bourgeois conditions of production, free trade, free selling and buying.

But if selling and buying disappears, free selling and buying dis-

appears also. This talk about free selling and buying, and all the other "brave words" of our bourgeoisie about freedom in general, have a meaning, if any, only in contrast with restricted selling and buying, with the fettered traders of the middle ages, but have no meaning when opposed to the Communistic abolition of buying and selling, of the bourgeois conditions of production, and of the bourgeoisie itself.

You are horrified at our intending to do away with private property. But in your existing society private property is already done away with for nine-tenths of the population; its existence for the few is solely due to its non-existence in the hands of those nine-tenths. You reproach us, therefore, with intending to do away with a form of property, the necessary condition for whose existence is the non-existence of any property for the immense majority of society.

In one word, you reproach us with intending to do away with your property. Precisely so: that is just what we intend.

From the moment when labor can no longer be converted into capital, money, or rent, into a social power capable of being monopolized, *i. e.*, from the moment when individual property can no longer be transformed into bourgeois property, into capital, from that moment, you say, individuality vanishes!

You must therefore confess, that by "individual" you mean no other person than the bourgeois, than the middle class owner of property. This person must, indeed, be swept out of the way, and made impossible.

Communism deprives no man of the power to appropriate the products of society: all that it does is to deprive him of the power to subjugate the labor of others by means of such appropriation.

It has been objected, that upon the abolition of private property all work will cease and universal laziness will overtake us.

According to this, bourgeois society ought long ago to have gone to the dogs through sheer idleness; for those of its members who work, acquire nothing, and those who acquire anything, do not work. The whole of this objection is but another expression of tautology, that there can no longer be any wage-labor when there is no longer any capital.

All objections against the Communistic mode of producing and appropriating material products have, in the same way, been urged against the Communistic modes of producing and appropriating intellectual products. Just as, to the bourgeois, the disappearance of class property is the disappearance of production itself, so the disappearance

of class culture is to him identical with the disappearance of all culture.

That culture, the loss of which he laments, is, for the enormous majority, a mere training to act as a machine.

But don't wrangle with us so long as you apply to our intended abolition of bourgeois property, the standard of your bourgeois notions of freedom, culture, law, etc. Your very ideas are but the outgrowth of the conditions of your bourgeois production and bourgeois property, just as your jurisprudence is but the will of your class made into a law for all, a will, whose essential character and direction are determined by the economical conditions of existence of your class.

The selfish misconception that induces you to transform into eternal laws of nature and of reason, the social forms springing from your present mode of production and form of property—historical relations that rise and disappear in the progress of production—the misconception you share with every ruling class that has preceded you. What you see clearly in the case of ancient property, what you admit in the case of feudal property, you are of course forbidden to admit in the case of your own bourgeois form of property.

Abolition of the family! Even the most radical flare up at this infamous proposal of the Communists.

On what foundation is the present family, the bourgeois family, based? On capital, on private gain. In its completely developed form this family exists only among the bourgeoisie. But this state of things finds its complement in the practical absence of the family among the proletarians, and in public prostitution.

The bourgeois family will vanish as a matter of course when its complement vanishes, and both will vanish with the vanishing of capital.

Do you charge us with wanting to stop the exploitation of children by their parents? To this crime we plead guilty.

But, you will say, we destroy the most hallowed of relations, when we replace home education by social.

And your education! Is not that also social, and determined by the social conditions under which you educate, by the intervention, direct or indirect, of society by means of schools, etc.? The Communists have not invented the intervention of society in education; but they do seek to alter the character of that intervention, and to rescue education from the influence of the ruling class.

The bourgeois clap-trap about the family and education, about the hallowed co-relation of parent and child become all the more disgusting,

as, by the action of modern industry, all family ties among the proletarians are torn asunder, and their children transformed into simple articles of commerce and instruments of labor.

But you Communists would introduce community of women, screams the whole bourgeoisie in chorus.

The bourgeois sees in his wife a mere instrument of production. He hears that the instruments of production are to be exploited in common, and naturally can come to no other conclusion than that the lot of being common to all will likewise fall to the women.

He has not even a suspicion that the real point aimed at is to do away with the status of women as mere instruments of production.

For the rest nothing is more ridiculous than the virtuous indignation of our bourgeois at the community of women which, they pretend, is to be openly and officially established by the Communists. The Communists have no need to introduce community of women; it has existed almost from time immemorial.

Our bourgeois, not content with having the wives and daughters of their proletarians at their disposal, not to speak of common prostitutes, take the greatest pleasure in seducing each other's wives.

Bourgeois marriage is in reality a system of wives in common, and thus, at the most, what the Communists might possibly be reproached with, is that they desire to introduce, in substitution for a hypocritically concealed, an openly legalized community of women. For the rest it is self-evident that the abolition of the present system of production must bring with it the abolition of the community of women springing from that system, *i. e.*, of prostitution, both public and private.

The Communists are further reproached with desiring to abolish countries and nationality.

The workingmen have no country. We cannot take from them what they have not got. Since the proletariat must first of all acquire political supremacy, must rise to be the leading class of the nation, must constitute itself the nation, it is, so far, itself national, though not in the bourgeois sense of the word.

National differences and antagonisms between peoples are daily more and more vanishing, owing to the development of the bourgeoisie, to freedom of commerce, to the world's market, to uniformity in the mode of production and in the conditions of life corresponding thereto.

The supremacy of the proletariat will cause them to vanish still faster. United action, of the leading civilized countries at least, is one of the first conditions for the emancipation of the proletariat.

In proportion as the exploitation of one individual by another is put an end to, the exploitation of one nation by another will also be put an end to. In proportion as the antagonism between classes within the nation vanishes, the hostility of one nation to another will come to an end.

The charges against Communism made from a religious, a philosophical, and, generally, from an ideological standpoint are not deserving of serious examination.

Does it require deep intuition to comprehend that man's ideas, views, and conceptions, in one word, man's consciousness, changes with every change in the conditions of his material existence, in his social relations and in his social life?

What else does the history of ideas prove, than that intellectual production changes its character in proportion as material production is changed? The ruling ideas of each age have ever been the ideas of its ruling class.

When people speak of ideas that revolutionize society they do but express the fact that within the old society the elements of a new one have been created, and that the dissolution of the old ideas keeps even pace with the dissolution of the old conditions of existence.

When the ancient world was in its last throes the ancient religions were overcome by Christianity. When Christian ideas succumbed in the eighteenth century to rationalist ideas, feudal society fought its death battle with the then revolutionary bourgeoisie. The ideas of religious liberty and freedom of conscience merely gave expression to the sway of free competition within the domain of knowledge.

"Undoubtedly," it will be said, "religious, moral, philosophical and juridical ideas have been modified in the course of historical development. But religion, morality, philosophy, political science, and law, constantly survived this change."

"There are besides eternal truths, such as Freedom, Justice, etc., that are common to all states of society. But Communism abolishes eternal truths, it abolishes all religion and all morality, instead of constituting them on a new basis; it therefore acts in contradiction to all past historical experience."

What does this accusation reduce itself to? The history of all past society has consisted in the development of class antagonisms, antagonisms that assumed different forms at different epochs.

But whatever form they may have taken, one fact is common to all

past ages, viz., the exploitation of one part of society by the other. No wonder, then, that the social consciousness of past ages, despite all the multiplicity and variety it displays, moves within certain common forms, or general ideas, which cannot completely vanish except with the total disappearance of class antagonisms.

The Communist revolution is the most radical rupture with traditional property relations; no wonder that its development involves the most radical rupture with traditional ideas.

But let us have done with the bourgeois objections to Communism.

We have seen above that the first step in the revolution by the working class is to raise the proletariat to the position of the ruling class; to win the battle of democracy.

The proletariat will use its political supremacy to wrest, by degrees, all capital from the bourgeoisie; to centralize all instruments of production in the hands of the State, *i. e.*, of the proletariat organized as the ruling class; and to increase the total of productive forces as rapidly as possible.

Of course, in the beginning this cannot be effected except by means of despotic inroads on the rights of property and on the conditions of bourgeois production; by means of measures, therefore, which appear economically insufficient and untenable, but which, in the course of the movement, outstrip themselves, necessitate further inroads upon the old social order and are unavoidable as a means of entirely revolutionizing the mode of production.

These measures will, of course, be different in different countries.

Nevertheless in the most advanced countries the following will be pretty generally applicable:

1. Abolition of property in land and application of all rents of land to public purposes.

2. A heavy progressive or graduated income tax.

3. Abolition of all right of inheritance.

4. Confiscation of the property of all emigrants and rebels.

5. Centralization of credit in the hands of the State, by means of a national bank with State capital and an exclusive monopoly.

6. Centralization of the means of communication and transport in the hands of the State.

7. Extension of factories and instruments of production owned by the State; the bringing into cultivation of waste lands, and the improvement of the soil generally in accordance with a common plan.

8. Equal liability of all to labor. Establishment of industrial armies, especially for agriculture.

9. Combination of agriculture with manufacturing industries; gradual abolition of the distinction between town and country, by a more equable distribution of the population over the country.

10. Free educaton for all children in public schools. Abolition of children's factory labor in its present form. Combination of education with industrial production, etc., etc.

When, in the course of development, class distinctions have disappeared and all production has been concentrated in the hands of a vast association of the whole nation, the public power will lose its political character. Political power, properly so called, is merely the organized power of one class for oppressing another. If the proletariat during its contest with the bourgeoisie is compelled, by the force of circumstances, to organize itself as a class, if, by means of a revolution, it makes itself the ruling class, and, as such, sweeps away by force the old conditions of production, then it will, along with these conditions, have swept away the conditions for the existence of class antagonisms, and of classes generally, and will thereby have abolished its own supremacy as a class.

In place of the old bourgeois society with its classes and class antagonisms we shall have an association in which the free development of each is the condition for the free development of all.

FRIEDRICH ENGELS

FRIEDRICH ENGELS was born at Barmen, Germany, 1820. He was a lifelong friend of Karl Marx and with him is one of the founders of German socialism. Since 1842 he lived mostly in England. He died in 1896.

SCIENTIFIC SOCIALISM

The new German philosophy culminated in the Hegelian system. In this system—and herein is its great merit—for the first time the whole world, natural, historical, intellectual, is represented as a process, *i. e.,* as in constant motion, change, transformation, development; and the attempt is made to trace out the internal connection that makes a continuous whole of all this movement and development. From this point of view the history of mankind no longer appeared as a wild whirl of senseless deeds of violence, all equally condemnable at the judgment seat of mature philosophic reason, and which are best forgotten as quickly as possible; but as the process of evolution of man himself. It was now the task of the intellect to follow the gradual march of this process through all its devious ways, and to trace out the inner law running through all its apparently accidental phenomena.

That the Hegelian system did not solve the problem it propounded is here immaterial. Its epoch-making merit was that it propounded the problem. This problem is one that no single individual will ever be able to solve. Although Hegel was—with Saint Simon—the most encyclopædic mind of his time, yet he was limited, first, by the necessarily limited extent of his own knowledge, and, second, by the limited extent and depth of the knowledge and conceptions of his age. To these limits a third must be added. Hegel was an idealist. To him the thoughts within his brain were not the more or less abstract pictures of actual things and processes, but, conversely, things and their evolution were only the realised pictures of the "Idea," existing somewhere from eternity before the world was. This way of thinking turned everything

upside down, and completely reversed the actual connection of things in the world. Correctly and ingeniously as many individual groups of facts were grasped by Hegel, yet, for the reasons just given, there is much that is botched, artificial, laboured, in a word, wrong in point of detail. The Hegelian system, in itself, was a colossal miscarriage—but it was also the last of its kind. It was suffering, in fact, from an internal and incurable contradiction. Upon the one hand, its essential proposition was the conception that human history is a process of evolution, which, by its very nature, cannot find its intellectual final term in the discovery of any so-called absolute truth. But, on the other hand, it laid claim to being the very essence of this absolute truth. A system of natural and historical knowledge, embracing everything, and final for all time, is a contradiction to the fundamental law of dialectic reasoning. This law, indeed, by no means excludes, but, on the contrary, includes the idea that the systematic knowledge of the external universe can make giant strides from age to age.

The perception of the fundamental contradiction in German idealism led necessarily back to materialism, but *nota bene,* not to the simply metaphysical, exclusively mechanical materialism of the eighteenth century. Old materialism looked upon all previous history as a crude heap of irrationality and violence; modern materialism sees in it the process of evolution of humanity, and aims at discovering the laws thereof. With the French of the eighteenth century, and even with Hegel, the conception obtained of Nature as a whole, moving in narrow circles, and forever immutable, with its eternal celestial bodies, as Newton, and unalterable organic species, as Linnæus taught. Modern materialism embraces the more recent discoveries of natural science, according to which Nature also has its history in time, the celestial bodies, like the organic species that, under favourable conditions, people them, being born and perishing. And even if Nature, as a whole, must still be said to move in recurrent cycles, these cycles assume infinitely larger dimensions. In both aspects, modern materialism is essentially dialectic, and no longer requires the assistance of that sort of philosophy which, queen-like, pretended to rule the remaining mob of sciences. As soon as each special science is bound to make clear its position in the great totality of things and of our knowledge of things, a special science dealing with this totality is superfluous or unnecessary. That which still survives of all earlier philosophy is the science of thought and its laws—formal logic and dialectics. Everything else is subsumed in the positive science of Nature and history.

Whilst, however, the revolution in the conception of Nature could only be made in proportion to the corresponding positive materials furnished by research, already much earlier certain historical facts had occurred which led to a decisive change in the conception of history. In 1831, the first working-class rising took place in Lyons; between 1838 and 1842, the first national working-class movement, that of the English Chartists, reached its height. The class struggle between proletariat and bourgeoisie came to the front in the history of the most advanced countries in Europe, in proportion to the development, upon the one hand, of modern industry, upon the other, of the newly-acquired political supremacy of the bourgeoisie. Facts more and more strenuously gave the lie to the teachings of bourgeois economy as to the identity of the interests of capital and labour, as to the universal harmony and universal prosperity that would be the consequence of unbridled competition. All these things could no longer be ignored, any more than the French and English Socialism, which was their theoretical, though very imperfect, expression. But the old idealist conception of history, which was not yet dislodged, knew nothing of class struggles based upon economic interests, knew nothing of economic interests; production and all economic relations appeared in it only as incidental, subordinate elements in the "history of civilisation."

The new facts made imperative a new examination of all past history. Then it was seen that *all* past history, with the exception of its primitive stages, was the history of class struggles; that these warring classes of society are always the products of the modes of production and of exchange—in a word, of the *economic* conditions of their time; that the economic structure of society always furnishes the real basis, starting from which we can alone work out the ultimate explanation of the whole superstructure of juridical and political institutions, as well as of the religious, philosophical, and other ideas of a given historical period. Hegel had freed history from metaphysics—he had made it dialectic; but his conception of history was essentially idealistic. But now idealism was driven from its last refuge, the philosophy of history; now a materialistic treatment of history was propounded, and a method found of explaining man's "knowing" by his "being," instead of, as heretofore, his "being" by his "knowing."

From that time forward Socialism was no longer an accidental discovery of this or that ingenious brain, but the necessary outcome of the struggle between two historically developed classes—the proletariat and the bourgeoisie. Its task was no longer to manufacture a system of

society as perfect as possible, but to examine the historico-economic succession of events from which these classes and their antagonism had of necessity sprung, and to discover in the economic conditions thus created the means of ending the conflict. But the Socialism of earlier days was incompatible with this materialistic conception as the conception of Nature of the French materialists was with dialectics and modern natural science. The Socialism of earlier days certainly criticised the existing capitalistic mode of production and its consequences. But it could not expiain them, and therefore could not get the mastery of them. It could only simply reject them as bad. The more strongly this earlier Socialism denounced the exploitation of the working-class, inevitable under Capitalism, the less able was it clearly to show in what this exploitation consisted and how it arose. But for this it was necessary—(1) to present the capitalistic method of production in its historical connection and its inevitableness during a particular historical period, and therefore, also, to present its inevitable downfall; and (2) to lay bare its essential character, which was still a secret. This was done by the discovery of *surplus-value*. It was shown that the appropriation of unpaid labour is the basis of the capitalist mode of production and of the exploitation of the worker that occurs under it; that even if the capitalist buys the labour-power of his labourer at its full value as a commodity on the market, he yet extracts more value from it than he paid for; and that in the ultimate analysis this surplus-value forms those sums of value from which are heaped up the constantly increasing masses of capital in the hands of the possessing classes. The genesis of capitalist production and the production of capital were both explained.

These two great discoveries, the materialistic conception of history and the revelation of the secret of capitalistic production through surplus-value, we owe to Marx. With these discoveries Socialism became a science. The next thing was to work out all its details and relations.

The materialist conception of history starts from the proposition that the production of the means to support human life and, next to production, the exchange of things produced, is the basis of all social structure; that in every society that has appeared in history, the manner in which wealth is distributed and society divided into classes or orders, is dependent upon what is produced, how it is produced, and how the products are exchanged. From this point of view the final causes of all social changes and political revolutions are to be sought, not in men's brains, not in man's better insight into eternal truth and justice, but in

changes in the modes of production and exchange. They are to be sought, not in the *philosophy,* but in the *economics* of each particular epoch. The growing perception that existing social institutions are unreasonable and unjust, that reason has become unreason, and right wrong, is only proof that in the modes of production and exchange changes have silently taken place, with which the social order, adapted to earlier economic conditions, is no longer in keeping. From this it also follows that the means of getting rid of the incongruities that have been brought to light, must also be present, in a more or less developed condition, within the changed modes of production themselves. These means are not to be invented by deduction from fundamental principles, but are to be discovered in the stubborn facts of the existing system of production.

What is, then, the position of modern Socialism in this connexion?

The present structure of society—this is now pretty generally conceded—is the creation of the ruling class of to-day, of the bourgeoisie. The mode of production peculiar to the bourgeoisie, known, since Marx, as the capitalist mode of production, was incompatible with the feudal system, with the privileges it conferred upon individuals, entire social ranks and local corporations, as well as with the hereditary ties of subordination which constituted the framework of its social organisation. The bourgeoisie broke up the feudal system and built upon its ruins the capitalist order of society, the kingdom of free competition, of personal liberty, of the equality, before the law, of all commodity owners, of all the rest of the capitalist blessings. Thenceforward the capitalist mode of production could develop in freedom. Since steam, machinery, and the making of machines by machinery transformed the older manufacture into modern industry, the productive forces evolved under the guidance of the bourgeoisie developed with a rapidity and in a degree unheard of before. But just as the older manufacture, in its time, and handicraft, becoming more developed under its influence, had come into collision with the feudal trammels of the guilds, so now modern industry, in its more complete development, comes into collision with the bounds within which the capitalistic mode of production holds it confined. The new productive forces have already outgrown the capitalistic mode of using them. And this conflict between productive forces and modes of production is not a conflict engendered in the mind of man, like that between original sin and divine justice. It exists, in fact, objectively, outside us, independently of the will and actions even of the men that have brought it on. Modern Socialism is nothing but the

reflex, in thought, of this conflict in fact; its ideal reflection in the minds, first, of the class directly suffering under it, the working-class.

Now, in what does this conflict consist?

Before capitalistic production, *i. e.*, in the Middle Ages, the system of petty industry obtained generally, based upon the private property of the labourers in their means of production; in the country, the agriculture of the small peasant, freeman or serf; in the towns, the handicrafts organized in guilds. The instruments of labour—land, agricultural implements, the workshop, the tool—were the instruments of labour of single individuals, adapted for the use of one worker, and, therefore, of necessity, small, dwarfish, circumscribed. But, for this very reason they belonged, as a rule, to the producer himself. To concentrate these scattered, limited means of production, to enlarge them, to turn them into the powerful levers of production of the present day—this was precisely the historic rôle of capitalist production and of its upholder, the bourgeoisie. In the fourth section of "Capital" Marx has explained in detail, how since the fifteenth century this has been historically worked out through the three phases of simple co-operation, manufacture and modern industry. But the bourgeoisie, as is also shown there, could not transform these puny means of production into mighty productive forces, without transforming them, at the same time, from means of production of the individual into *social* means of production only workable by a collectivity of men. The spinning-wheel, the handloom, the blacksmith's hammer, were replaced by the spinning-machine, the power-loom, the steam-hammer; the individual workshop, by the factory implying the co-operation of hundreds and thousands of workmen. In like manner, production itself changed from a series of individual into a series of social acts, and the products from individual to social products. The yarn, the cloth, the metal articles that now came out of the factory were the joint product of many workers, through whose hands they had successively to pass before they were ready. No one person could say of them: "I made that; this is my product."

But where, in a given society, the fundamental form of production is that spontaneous division of labour which creeps in gradually and not upon any preconceived plan, there the products take on the form of commodities, whose mutual exchange, buying and selling, enable the individual producers to satisfy their manifold wants. And this was the case in the Middle Ages. The peasant, *e. g.*, sold to the artisan agricultural products and bought from him the products of handicraft. Into

this society of individual producers, of commodity-producers, the new mode of production thrust itself. In the midst of the old division of labour, grown up spontaneously and upon *no definite plan,* which had governed the whole of society, now arose division of labour upon a definite plan, as organised in the factory; side by side with *individual* production appeared *social* production. The products of both were sold in the same market, and, therefore, at prices at least approximately equal. But organisation upon a definite plan was stronger than spontaneous division of labour. The factories working with the combined social forces of a collectivity of individuals produced their commodities far more cheaply than the individual small producers. Individual production succumbed in one department after another. Socialised production revolutionised all the old methods of production. But its revolutionary character was, at the same time, so little recognised, that it was, on the contrary, introduced as a means of increasing and developing the production of commodities. When it arose, it found ready-made, and made liberal use of, certain machinery for the production and exchange of commodities; merchants' capital, handicraft, wage-labour. Socialised production thus introducing itself as a new form of the production of commodities, it was a matter of course that under it the old forms of appropriation remained in full swing, and were applied to its products as well.

In the mediæval stage of evolution of the production of commodities, the question as to the owner of the product of labour could not arise. The individual producer, as a rule, had, from raw material belonging to himself, and generally his own handiwork, produced it with his own tools, by the labour of his own hands or of his family. There was no need for him to appropriate the new product. It belonged wholly to him, as a matter of course. His property in the product was, therefore, based *upon his own labour.* Even where external help was used, this was, as a rule, of little importance, and very generally was compensated by something other than wages. The apprentices and journeymen of the guilds worked less for board and wages than for education, in order that they might become master craftsmen themselves.

Then came the concentration of the means of production and of the producers in large workshops and manufactories, their transformation into actual socialised means of production and socialised producers. But the socialised producers and means of production and their products were still treated, after this change, just as they had been before,

i. e., as the means of production and the products of individuals. Hitherto, the owner of the instruments of labour had himself appropriated the product, because, as a rule, it was his own product and the assistance of others was the exception. Now the owner of the instruments of labour always appropriated to himself the product, although it was no longer *his* product, but exclusively the product of the *labour of others.* Thus, the products now produced socially were not appropriated by those who had actually set in motion the means of production and actually produced the commodities, but by the *capitalists.* The means of production, and production itself, had become in essence socialised. But they were subjected to a form of appropriation which presupposes the private production of individuals, under which, therefore, every one owns his own product and brings it to market. The mode of production is subjected to this form of appropriation, although it abolishes the conditions upon which the latter rests.

This contradiction, which gives to the new mode of production its capitalistic character, *contains the germ of the whole of the social antagonisms of to-day.* The greater the mastery obtained by the new mode of production over all important fields of production and in all manufacturing countries, the more it reduced individual production to an insignificant residuum, *the more clearly was brought out the incompatibility of socialised production with capitalistic appropriation.*

The first capitalists found, as we have said, alongside of other forms of labour, wage-labour ready-made for them on the market. But it was exceptional, complementary, accessory, transitory wage-labour. The agricultural labourer, though, upon occasion, he hired himself out by the day, had a few acres of his own land on which he could at all events live at a pinch. The guilds were so organised that the journeyman of to-day became the master of to-morrow. But all this changed, as soon as the means of production became socialised and concentrated in the hands of capitalists. The means of production, as well as the product, of the individual producer became more and more worthless; there was nothing left for him but to turn wage-worker under the capitalist. Wage-labour, aforetime the exception and accessory, now became the rule and basis of all production; aforetime complementary, it now became the sole remaining function of the worker. The wage-worker for a time became a wage-worker for life. The number of these permanent wage-workers was further enormously increased by the breaking-up of the feudal system that occurred at the same time, by the disbanding of the retainers of the feudal lords, the eviction of the

peasants from their homesteads, etc. The separation was made complete between the means of production concentrated in the hands of the capitalists on the one side, and the producers, possessing nothing but their labour-power, on the other. *The contradiction between socialised production and capitalistic appropriation manifested itself as the antagonism of proletariat and bourgeoisie.*

We have seen that the capitalistic mode of production thrust its way into a society of commodity-producers, of individual producers, whose social bond was the exchange of their products. But every society, based upon the production of commodities, has this peculiarity: that the producers have lost control over their own social inter-relations. Each man produces for himself with such means of production as he may happen to have, and for such exchange as he may require to satisfy his remaining wants. No one knows how much of his particular article is coming on the market, nor how much of it will be wanted. No one knows whether his individual product will meet an actual demand, whether he will be able to make good his cost of production or even to sell his commodity at all. Anarchy reigns in socialised production.

But the production of commodities, like every other form of production, has its peculiar, inherent laws inseparable from it; and these laws work, despite anarchy, in and through anarchy. They reveal themselves in the only persistent form of social inter-relations, *i. e.*, in exchange, and here they affect the individual producers as compulsory laws of competition. They are, at first, unknown to these producers themselves, and have to be discovered by them gradually and as the result of experience. They work themselves out, therefore, independently of the producers, and in antagonism to them, as inexorable natural laws of their particular form of production. The product governs the producers.

In mediæval society, especially in the earlier centuries, production was essentially directed towards satisfying the wants of the individual. It satisfied, in the main, only the wants of the producer and his family. Where relations of personal dependence existed, as in the country, it also helped to satisfy the wants of the feudal lord. In all this there was, therefore, no exchange; the products, consequently, did not assume the character of commodities. The family of the peasant produced almost everything they wanted; clothes and furniture, as well as means of subsistence. Only when it began to produce more than was sufficient to supply its own wants and the payments in kind to the feudal lord, only

then did it also produce commodities. This surplus, thrown into socialised exchange and offered for sale, became commodities.

The artisans of the towns, it is true, had from the first to produce for exchange. But they, also, themselves supplied the greatest part of their own individual wants. They had gardens and plots of land. They turned their cattle out into the communal forest, which, also, yielded them timber and firing. The women spun flax, wool, and so forth. Production for the purpose of exchange, production of commodities, was only in its infancy. Hence, exchange was restricted, the market narrow, the methods of production stable; there was local exclusiveness without, local unity within; the mark in the country, in the town, the guild.

But with the extension of the production of commodities, and especially with the introduction of the capitalist mode of production, the laws of commodity-production, hitherto latent, came into action more openly and with greater force. The old bonds were loosened, the old exclusive limits broken through, the producers were more and more turned into independent, isolated producers of commodities. It became apparent that the production of society at large was ruled by absence of plan, by accident, by anarchy; and this anarchy grew to greater and greater height. But the chief means by aid of which the capitalist mode of production intensified this anarchy of socialised production, was the exact opposite of anarchy. It was the increasing organisation of production, upon a social basis, in every individual productive establishment. By this, the old, peaceful, stable condition of things was ended. Wherever this organisation of production was introduced into a branch of industry, it brooked no other method of production by its side. The field of labour became a battle-ground. The great geographical discoveries, and the colonisation following upon them, multiplied markets and quickened the transformation of handicraft into manufacture. The war did not simply break out between the individual producers of particular localities. The local struggles begat in their turn national conflicts, the commercial wars of the seventeenth and the eighteenth centuries.

Finally, modern industry and the opening of the world-market made the struggle universal, and at the same time gave it an unheard-of virulence. Advantages in natural or artificial conditions of production now decide the existence or non-existence of individual capitalists, as well as of whole industries and countries. He that falls is remoselessly cast aside. It is the Darwinian struggle of the individual for existence transferred from Nature to society with intensified violence. The con-

ditions of existence natural to the animal appear as the final term of human development. The contradiction between socialised production and capitalistic appropriation now presents itself as *an antagonism between the organisation of production in the individual workshop and the anarchy of production in society generally.*

The capitalistic mode of production moves in these two forms of the antagonism immanent to it from its very origin. It is never able to get out of that "vicious circle," which Fourier had already discovered. What Fourier could not, indeed, see in his time, is, that this circle is gradually narrowing; that the movement becomes more and more a spiral, and must come to an end, like the movement of the planets, by collision with the centre. It is the compelling force of anarchy in the production of society at large that more and more completely turns the great majority of men into proletarians; and it is the masses of the proletariat again who will finally put an end to anarchy in production. It is the compelling force of anarchy in social production that turns the limitless perfectibility of machinery under modern industry into a compulsory law by which every individual industrial capitalist must perfect his machinery more and more, under penalty of ruin.

But the perfecting of machinery is the making human labour superfluous. If the introduction and increase of machinery means the displacement of millions of manual, by a few machine workers, improvement in machinery means the displacement of more and more of the machine-workers themselves. It means, in the last instance, the production of a number of available wage-workers in excess of the average needs of capital, the formation of a complete industrial reserve army, as I called it in 1845, available at the times when industry is working at high pressure, to be cast out upon the street when the inevitable crash comes, a constant dead weight upon the limbs of the working-class in its struggle for existence with capital, a regulator for the keeping of wages down to the low level that suits the interests of capital. Thus it comes about, to quote Marx, that machinery becomes the most powerful weapon in the war of capital against the working-class; that the instruments of labour constantly tear the means of subistence out of the hands of the labourer; that the very product of the worker is turned into an instrument for his subjugation. Thus it comes about that the economising of the instruments of labour becomes at the same time, from the outset, the most reckless waste of labour-power, and robbery based upon the normal conditions under which labour functions; that machinery, "the most powerful instrument for shortening labour-time, becomes

the most unfailing means for placing every moment of the labourer's time and that of his family at the disposal of the capitalist for the purpose of expanding the value of his capital" ("Capital," English edition, p. 406). Thus it comes about that over-work of some becomes the preliminary condition for the idleness of others, and that modern industry, which hunts after new consumers over the whole world, forces the consumption of the masses at home down to a starvation minimum, and in doing thus destroys its own home market. "The law that always equilibrates the relative surplus population, or industrial reserve army, to the extent and energy of accumulation, this law rivets the labourer to capital more firmly than the wedges of Vulcan did Prometheus to the rock. It establishes an accumulation of misery, corresponding with accumulation of capital. Accumulation of wealth at one pole is, therefore, at the same time, accumulation of misery, agony of toil, slavery, ignorance, brutality, mental degradation, at the opposite pole, *i. e.*, on the side of the class that produces *its own product in the form of capital.*" (Marx' "Capital" [Sonnenschein & Co.], p. 661.) And to expect any other division of the products from the capitalistic mode of production is the same as expecting the electrodes of a battery not to decompose acidulated water, not to liberate oxygen at the positive, hydrogen at the negative pole, so long as they are connected with the battery.

We have seen that the ever-increasing perfectibility of modern machinery is, by the anarchy of social production, turned into a compulsory law that forces the individual industrial capitalist always to improve his machinery, always to increase its productive force. The bare possibility of extending the field of production is transformed for him into a similar compulsory law. The enormous expansive force of modern industry, compared with which that of gases is mere child's play, appears to us now as a *necessity* for expansion, both qualitative and quantitative, that laughs at all resistance. Such resistance is offered by consumption, by sales, by the markets for the products of modern industry. But the capacity for extension, extensive and intensive, of the markets is primarily governed by quite different laws, that work much less energetically. The extension of the markets cannot keep pace with the extension of production. The collision becomes inevitable, and as this cannot produce any real solution so long as it does not break in pieces the capitalist mode of production, the collisions become periodic. Capitalists production has begotten another "vicious circle."

As a matter of fact, since 1825, when the first general crisis broke out, the whole industrial and commercial world, production and exchange among all civilised peoples and their more or less barbaric hangers-on, are thrown out of joint about once every ten years. Commerce is at a standstill, the markets are glutted, products accumulate, as multitudinous as they are unsalable, hard cash disappears, credit vanishes, factories are closed, the mass of the workers are in want of the means of subsistence, because they have produced too much of the means of subsistence; bankruptcy follows upon bankruptcy, execution upon execution. The stagnation lasts for years; productive forces and products are wasted and destroyed wholesale, until the accumulated mass of commodities finally filter off, more or less depreciated in value, until production and exchange gradually begin to move again. Little by little the pace quickens. It becomes a trot. The industrial trot breaks into a canter, the canter in turn grows into the headlong gallop of a perfect steeplechase of industry, commercial credit, and speculation, which finally, after breakneck leaps, ends where it began—in the ditch of a crisis. And so over and over again. We have now, since the year 1825, gone through this five times, and at the present moment (1877) we are going through it for the sixth time. And the character of these crises is so clearly defined that Fourier hit all of them off, when he described the first as "*crise plethorique,*" a crisis from plethora.

In these crises, the contradiction between socialised production and capitalist appropriation ends in a violent explosion. The circulation of commodities is, for the time being, stopped. Money, the means of circulation, becomes a hindrance to circulation. All the laws of production and circulation of commodities are turned upside down. The economic collision has reached its apogee. *The mode of production is in rebellion against the mode of exchange.*

The fact that the socialised organisation of production within the factory has developed so far that it has become incompatible with the anarchy of production in society, which exists side by side with and dominates it, is brought home to the capitalists themselves by the violent concentration of capital that occurs during crises, through the ruin of many large, and a still greater number of small, capitalists. The whole mechanism of the capitalist mode of production breaks down under the pressure of the productive forces, its own creations. It is no longer able to turn all this mass of means of production into capital. They lie fallow, and for that very reason the industrial reserve army must also lie

fallow. Means of production, means of subsistence, available labourers, all the elements of production and of general wealth, are present in abundance. But "abundance becomes the source of distress and want" (Fourier), because it is the very thing that prevents the transformation of the means of production and subsistence into capital. For in capitalistic society the means of production can only function when they have undergone a preliminary transformation into capital, into the means of exploiting human labour-power. The necessity of this transformation into capital of the means of production and subsistence stands like a ghost between these and the workers. It alone prevents the coming together of the material and personal levers of production; it alone forbids the means of production to function, the workers to work and live. On the one hand, therefore, the capitalistic mode of production stands convicted of its own incapacity to further direct these productive forces. On the other, these productive forces themselves, with increasing energy, press forward to the removal of the existing contradiction, to the abolition of their quality as capital, to the *practical recognition of their character as social productive forces.*

This rebellion of the productive forces, as they grow more and more powerful, against their quality as capital, this stronger and stronger command that their social character shall be recognised, forces the capitalist class itself to treat them more and more as social productive forces, so far as this is possible under capitalist conditions. The period of industrial high pressure, with its unbounded inflation of credit, not less than the crash itself, by the collapse of great capitalist establishments, tends to bring about that form of the socialisation of great masses of means of production, which we meet with in the different kinds of joint-stock companies. Many of these means of production and of distribution are, from the outset, so colossal, that, like the railroads, they exclude all other forms of capitalistic exploitation. At a further stage of evolution this form also becomes insufficient. The producers on a large scale in a particular branch of industry in a particular country unite in a "Trust," a union for the purpose of regulating production. They determine the total amount to be produced, parcel it out among themselves, and thus enforce the selling price fixed beforehand. But trusts of this kind, as soon as business becomes bad, are generally liable to break up, and, on this very account, compel a yet greater concentration of association. The whole of the particular industry is turned into one gigantic joint-stock com-

pany; internal competition gives place to the internal monopoly of this one company. This has happened in 1890 with the English alkali production, which is now, after the fusion of 48 large works, in the hands of one company, conducted upon a single plan, and with a capital of £6,000,000.

In the trusts, freedom of competition changes into its very opposite —into monopoly; and the production without any definite plan of capitalistic society capitulates to the production upon a definite plan of the invading socialistic society. Certainly this is so far still to the benefit and advantage of the capitalists. But in this case the exploitation is so palpable that it must break down. No nation will put up with production conducted by trusts, with so barefaced an exploitation of the community by a small band of dividend-mongers.

In any case, with trusts or without, the official representative of capitalist society—the State—will ultimately have to undertake the direction of production. This necessity for conversion into State-property is felt first in the great institutions for intercourse and communication—the post-office, the telegraphs, the railways.

If the crises demonstrate the incapacity of the bourgeoisie for managing any longer modern productive forces, the transformation of the great establishments for production and distribution into joint-stock companies, trusts, and State property, show how unnecessary the bourgeoisie are for that purpose. All the social functions of the capitalists are now performed by salaried employees. The capitalist has no further social function than that of pocketing dividends, tearing off coupons, and gambling on the Stock Exchange, where the different capitalists despoil one another of their capital. At first the capitalistic mode of production forces out the workers. Now it forces out the capitalists, and reduces them, just as it reduced the workers, to the ranks of the surplus population, although not immediately into those of the industrial reserve army.

But the transformation, either into joint-stock companies and trusts, or into State-ownership, does not do away with the capitalistic nature of the productive forces. In the joint-stock companies and trusts this is obvious. And the modern State, again, is only the organisation that bourgeois society takes on in order to support the external conditions of the capitalist mode of production against the encroachments, as well of the workers as of individual capitalists. The modern State, no matter what its form, is essentially a capitalistic machine, the state of the

capitalists, the ideal personification of the total national capital. The more it proceeds to the taking over of productive forces, the more does it actually become the national capitalist, the more the citizens does it exploit. The workers remain wage-workers—proletarians. The capitalist relation is not done away with. It is rather brought to a head. But, brought to a head, it topples over. State-ownership of the productive forces is not the solution of the conflict, but concealed within it are the technical conditions that form the elements of that solution.

This solution can only consist in the practical recognition of the social nature of the modern forces of production, and therefore in the harmonising the modes of production, appropriation, and exchange with the socialised character of the means of production. And this can only come about by society openly and directly taking possession of the productive forces which have outgrown all control except that of society as a whole. The social character of the means of production and of the products to-day reacts against the producers, periodically disrupts all production and exchange, acts only like a law of Nature working blindly, forcibly, destructively. But with the taking over by society of the productive forces, the social character of the means of production and of the products will be utilised by the producers with a perfect understanding of its nature, and instead of being a source of disturbance and periodical collapse, will become the most powerful lever of production itself.

Active social forces work exactly like natural forces: blindly, forcibly, destructively, so long as we do not understand, and reckon with, them. But when once we understand them, when once we grasp their action, their direction, their effects, it depends only upon ourselves to subject them more and more to our own will, and by means of them to reach our own ends. And this holds quite especially of the mighty productive forces of to-day. As long as we obstinately refuse to understand the nature and the character of these social means of action—and this understanding goes against the grain of the capitalist mode of production and its defenders—so long these forces are at work in spite of us, in opposition to us, so long they master us, as we have shown above in detail.

But when once their nature is understood, they can, in the hands of the producers working together, be transformed from master demons into willing servants. The difference is as that between the destructive force of electricity in the lightning of the storm, and electricity under

command in the telegraph and the voltaic arc; the difference between a conflagration, and fire working in the service of man. With this recognition at last of the real nature of the productive forces of to-day, the social anarchy of production gives place to a social regulation of production upon a definite plan, according to the needs of the community and of each individual. Then the capitalist mode of appropriation, in which the product enslaves first the producer and then the appropriator, is replaced by the mode of appropriation of the products that is based upon the nature of the modern means of production; upon the one hand, direct social appropriation, as means to the maintenance and extension of production—on the other, direct individual appropriation, as means of subsistence and of enjoyment.

Whilst the capitalist mode of production more and more completely transforms the great majority of the population into proletarians, it creates the power which, under penalty of its own destruction, is forced to accomplish this revolution. Whilst it forces on more and more the transformation of the vast means of production, already socialised, into State property, it shows itself the way to accomplishing this revolution. *The proletariat seizes political power and turns the means of production into State property.*

But, in doing this, it abolishes itself as proletariat, abolishes all class distinctions and class antagonisms, abolishes also the State as State. Society thus far, based upon class antagonisms, had need of the State. That is, of an organisation of the particular class which was *pro tempore* the exploiting class, an organisation for the purpose of preventing any interference from without with the existing conditions of production, and therefore, especially, for the purpose of forcibly keeping the exploited classses in the condition of oppression corresponding with the given mode of production (slavery, serfdom, wage-labour). The State was the official representative of society as a whole; the gathering of it together into a visible embodiment. But it was this only in so far as it was the State of that class which itself represented, for the time being, society as a whole; in ancient times, the State of slave-owning citizens; in the middle ages, the feudal lords; in our own time, the bourgeoisie. When at last it becomes the real representative of the whole of society, it renders itself unnecessary. As soon as there is no longer any social class to be held in subjection; as soon as class rule, and the individual struggle for existence based upon our present anarchy in production, with the collisions and excesses arising from these, are

removed, nothing more remains to be repressed, and a special repressive force, a State, is no longer necessary. The first act by virtue of which the State really constitutes itself the representative of the whole of society—the talking possession of the means of production in the name of society—this is, at the same time, its last independent act as a State. State interference in social relations becomes, in one domain after another, superfluous, and then dies out of itself; the government of persons is replaced by the administration of things, and by the conduct of processes of production. The State is not "abolished." *It dies out.* This gives the measure of the value of the phrase "a free State," both as to its justifiable use at times by agitators, and as to its ultimate scientific insufficiency; and also of the demands of the so-called anarchists for the abolition of the State out of hand.

Since the historical appearance of the capitalist mode of production, the appropriation by society of all the means of production has often been dreamed of, more or less vaguely, by individuals, as well as by sects, as the ideal of the future. But it could become possible, could become a historical necessity, only when the actual conditions for its realisation were there. Like every other social advance, it becomes practicable, not by men understanding that the existence of classes is in contradiction to justice, equality, etc., not by the mere willingness to abolish these classes, but by virtue of certain new economic conditions. The separation of society into an exploiting and an exploited class, a ruling and an oppressed class, was the necessary consequence of the deficient and restricted development of production in former times. So long as the total social labour only yields a produce which but slightly exceeds that barely necessary for the existence of all; so long, therefore, as labour engages all or almost all the time of the great majority of the members of society—so long, of necessity, this society is divided into classes. Side by side with the great majority, exclusively bond slaves to labour, arises a class freed from directly productive labour, which looks after the general affairs of society; the direction of labour, State business, law, science, art, etc. It is, therefore, the law of division of labour that lies at the basis of the division into classes. But this does not prevent this division into classes from being carried out by means of violence and robbery, trickery and fraud. It does not prevent the ruling class, once having the upper hand, from consolidating its power at the expense of the working-class, from turning their social leadership into an intensified exploitation of the masses.

But if, upon this showing, division into classes has a certain historical justification, it has this only for a given period, only under given social conditions. It was based upon the insufficiency of production. It will be swept away by the complete development of modern productive forces. And, in fact, the abolition of classes in society presupposes a degree of historical evolution, at which the existence, not simply of this or that particular ruling class, but of any ruling class at all, and, therefore, the existence of class distinction itself has become an obsolete anachronism. It presupposes, therefore, the development of production carried out to a degree at which appropriation of the means of production and of the products, and, with this, of political domination, of the monopoly of culture, and of intellectual leadership by a particular class of society, has become not only superfluous, but economically, politically, intellectually a hindrance to development.

This point is now reached. Their political and intellectual bankruptcy is scarcely any longer a secret to the bourgeoisie themselves. Their economic bankruptcy recurs regularly every ten years. In every crisis, society is suffocated beneath the weight of its own productive forces and products, which it cannot use, and stands helpless, face to face with the absurd contradiction that the producers have nothing to consume, because consumers are wanting. The expansive force of the means of production bursts the bonds that the capitalist mode of production had imposed upon them. Their deliverance from these bonds is the one pre-condition for an unbroken, constantly-accelerated development of the productive forces, and therewith for a practically unlimited increase of production itself. Nor is this all. The socialised appropriation of the means of production does away, not only with the present artificial restrictions upon production, but also with the positive waste and devastation of productive forces and products that are at the present time the inevitable concomitants of production, and that reach their height in the crises. Further, it sets free for the community at large a mass of means of production and of products, by doing away with the senseless extravagance of the ruling classes of to-day, and their political representatives. The possibility of securing for every member of society, by means of socialised production, an existence not only fully sufficient materially, and becoming day by day more full, but an existence guaranteeing to all the free development and exercise of their physical and mental faculties—this possibility is now for the first time here, but *it is here.*

With the seizing of the means of production by society, production of commodities is done away with, and, simultaneously, the mastery of the product over the producer. Anarchy in social production is replaced by systematic, definite organisation. The struggle for individual existence disappears. Then for the first time, man, in a certain sense, is finally marked off from the rest of the animal kingdom, and emerges from mere animal conditions of existence into really human ones. The whole sphere of the conditions of life which environ man, and which have hitherto ruled man, now comes under the dominion and control of man, who for the first time becomes the real, conscious lord of Nature, because he has now become master of his own social organisation. The laws of his own social action, hitherto standing face to face with man as laws of Nature foreign to, and dominating, him, will then be used with full understanding, and so mastered by him. Man's own social organisation, hitherto confronting him as a necessity imposed by Nature and history, now becomes the result of his own free action. The extraneous objective forces that have hitherto governed history, pass under the control of man himself. Only from that time will man himself, more and more consciously, make his own history—only from that time will the social causes set in movement by him have, in the main and in a constantly growing measure, the results intended by him. It is the ascent of man from the kingdom of necessity to the kingdom of freedom.

Let us briefly sum up our sketch of historical evolution.

I. Mediæval Society.—Individual production on a small scale. Means of production adapted for individual use; hence primitive, ungainly, petty, dwarfed in action. Production for immediate consumption, either of the producer himself or of his feudal lord. Only where an excess of production over this consumption occurs is such excess offered for sale, enters into exchange. Production of commodities, therefore, only in its infancy. But already it contains within itself, in embryo, ***anarchy in the production of society at large.***

II. Capitalist Revolution.—Transformation of industry, at first by means of simple co-operation and manufacture. Concentration of the means of production, hitherto scattered, into great workshops. As a consequence, their transformation from individual to social means of production—a transformation which does not, on the whole, affect the form of exchange. The old forms of appropriation remain in force. The capitalist appears. In his capacity as owner of the means of production, he also appropriates the products and turns them into com-

modities. Production has become a *social* act. Exchange and appropriation continue to be *individual* acts, the acts of individuals. *The social product is appropriated by the individual capitalist.* Fundamental contradiction, whence arise all the contradictions in which our present day society moves, and which modern industry brings to light.

A. Severance of the producer from the means of production. Condemnation of the worker to wage-labour for life. *Antagonism between the proletariat and the bourgeoisie.*

B. Growing predominance and increasing effectiveness of the laws governing the production of commodities. Unbridled competition. *Contradiction between socialised organisation in the individual factory and social anarchy in production as a whole.*

C. On the one hand, perfecting of machinery, made by competition compulsory for each individual manufacturer, and complemented by a constantly growing displacement of labourers. *Industrial reserve-army.* On the other hand, unlimited extension of production, also compulsory under competition, for every manufacturer. On both sides, unheard of development of productive forces, excess of supply over demand, over-production, glutting of the markets, crises every ten years, the vicious circle: excess here, of means of production and products—excess there, of labourers, without employment and without means of existence. But these two levers of production and of social well-being are unable to work together, because the capitalist form of production prevents the productive forces from working and the products from circulating, unless they are first turned into capital—which their very superabundance prevents. The contradiction has grown into an absurdity. *The mode of production rises in rebellion against the form of exchange.* The bourgeoisie are convicted of incapacity further to manage their own social productive forces.

D. Partial recognition of the social character of the productive forces forced upon the capitalists themselves. Taking over of the great institutions for production and communication, first by joint-stock companies, later on by trusts, then by the State. The bourgeoisie demonstrated to be a superfluous class. All its social functions are now performed by salaried employees.

III. Proletarian Revolution.—Solution of the contradictions. The proletariat seizes the public power, and by means of this transforms the socialised means of production, slipping from the hands of the bourgeoisie, into public property. By this act, the proletariat frees the

means of production from the character of capital they have thus far borne, and gives their socialised character complete freedom to work itself out. Socialised production upon a pre-determined plan becomes henceforth possible. The development of production makes the existence of different classes of society thenceforth an anachronism. In proportion as anarchy in social production vanishes, the political authority of the State dies out. Man, at last the master of his own form of social organisation, becomes at the same time the lord over Nature, his own master—free.

To accomplish this act of universal emancipation is the historical mission of the modern proletariat. To thoroughly comprehend the historical conditions and thus the very nature of this act, to impart to the now oppressed proletarian class a full knowledge of the conditions and of the meaning of the momentous act it is called upon to accomplish, this is the task of the theoretical expression of the proletarian movement, scientific Socialism.

INTERSTATE COMMERCE COMMISSION

As a result of the report of the special Senate committee on Interstate Commerce, the Interstate Commerce Act was passed February 4, 1887. The considerations that led to its passage are given below in the committee's report. The main provisions of the act are these:—

The act applies to interstate transportation only; it decrees that charges must be reasonable; that there shall be no unjust discrimination between shippers, in charges or service; nor between connecting lines; a common carrier cannot receive any greater compensation in the aggregate, under substantially similar circumstances for a shorter than longer distance over the same line in the same direction; pooling is made unlawful; schedules and charges must be posted, and ten days' notice given of an advance, three days of a reduction in rates; an interstate commerce commission of five commissioners, appointed by the President, is established; this may sit as a court to hear complaints, and its decisions and finding of fact shall be taken as *prima facie* evidence; officers may be compelled to testify, but their evidence shall not be used against

them in any criminal proceedings. In case of disobedience United States courts may be petitioned.

THE PUBLIC CONTROL OF RAILROADS

The introduction of the railroad brought into the world an untried and powerful force, the possibilities of which are even yet but imperfectly understood, and its operation brought important questions which of necessity were met and decided blindly, without the advantage of precedent or experience, and without any adequate appreciation of the unforeseen and manifold changes that have since resulted through its agency. During what may be termed the era of construction the chief consideration that influenced the people and the legislatures of Great Britain and America was how to secure railroads, not how to control them. It was many years before the necessity of control became apparent or the matters over which control was needed became understood. The construction of railroads was at first authorized by special charters. When the first charters were granted it was supposed that the railroad would be merely a modification of or an improvement upon the public highway; that it would simply furnish a line of communication open to all, like a canal, and that it could be used at pleasure, as a water route it used, by all who might be disposed to place upon it means of carriage. It was also supposed that the railroad would be used only for the carriage of passengers, and not for the transportation of freight, except perhaps to a limited extent. How thoroughly this misconception prevailed is illustrated by a report made to the New York legislature as late as 1835, in which the four leading engineers of that state expressed the following remarkable opinion:

> The railroads admit of advantageous use in districts where canals, for the want of water, would be impracticable. They will probably be preferred where high velocities are required, and for the transportation of passengers, and, *under some circumstances, for the conveyance of light goods.*

The supposed analogy between the railroad and the public highway in their relations to the community gave direction to the earlier legislation of England and the United States. And even when the discovery was made that there was an element of monopoly inseparably connected with the business of transportation by rail, the earlier efforts at regula-

tion were directed at the limitation of the profits of the corporation rather than towards the protection of the shipper.

The widely varying methods which have been adopted by different Governments in dealing with the problems of railway development and regulation may be grouped as follows:

1, The policy of private ownership and private management—

(*a*) Without interference or supervision by the Government.

(*b*) Subject to compulsory and penal legislation for control and regulation of rates.

(*c*) Subject to investigation by a commission with advisory powers, and depending largely upon public opinion for the enforcement of its recommendations.

(*d*) Subject to investigation by a commission with power to fix and regulate rates.

2. Exclusive State ownership and Government management.

3. State ownership and private management under Government supervision and control.

4. Partial State ownership and management in competition with private ownership and management.

Regulation through state ownership has been practically unknown in the United States. It is of foreign origin and is foreign to the character of our institutions. The time may come when the people of the United States will be forced to consider the advisability of placing the railways of the country completely under the control of the General Government, as the postal service is, and as many believe the telegraph service should be. This would seem to be the surest method of securing the highest perfect and the greatest efficiency of the railroad system in its entirety, and the best method of making it an harmonious whole in its operation and of bringing about that uniformity and stability of rates which is the greatest need of trade and commerce. But the dangers to be apprehended from the giving of such vast additional power to the Government will always prove a formidable barrier to the adoption of such a policy, and this committee sees no necessity for considering its advantages or disadvantages until other methods of regulation more American in spirit have at least been given a trial and have proved unsatisfactory. Nor is it deemed important to investigate in detail the experience of those European nations in which the policy of State ownership or management in one form or another has prevailed.

In those nations the railroad question has presented itself under different conditions, and has admitted of methods of regulation wholly impracticable in the United States, by reason of the marked differences in the organization of the machinery of government and in the customs,

temper, and habits of thought of the people. The English railroad system, however, has grown up under conditions more nearly resembling those prevailing upon this side of the Atlantic than those existing in any other country. It has been developed under the operation of the principle of private ownership and management, subject to Parliamentary control, and substantially all of the methods of regulation proposed in this country had first been tested there. The English people early undertook the legislative regulation of their railroads. They have been considerably in advance of us in dealing with the difficulties that have been encountered, and have given the subject no little attention.

For these reasons the experience of England is of more interest and value to us than that of those nations in which the policy of state ownership has been more or less generally adopted, and these reasons seem to warrant a glance at the efforts which have been made in that country for more than fifty years to unravel the complications of the railroad question, and to hit upon a satisfactory method of enforcing the performance of public obligations and of adjusting the relations between the railroads and the people. The information on these subjects herewith submitted is based largely upon the statements contained in the numerous reports which have been made by Parliamentary committees.

THE COURSE OF RAILROAD LEGISLATION IN ENGLAND—WORKINGS OF THE ENGLISH COMMISSION—THE PRESENT STATUS OF AFFAIRS

When railroad construction began in England that country already had quite a complete system of canals, with which the new methods of transportation came immediately into active competition. By the charters first granted the railroads were required to admit to their lines the cars and locomotives of other companies and individuals, and the acts usually prescribed the maximum tolls to be charged for such service. These were regulations which it had been found necessary to apply to the canals, in the management of which abuses had been complained of somewhat similar to those that afterwards characterized the management of railways. Competition between the different carriers who were expected to use the route was relied on to secure to the public needful facilities and fair rates under these provisions. But this was not the result, and within ten years after the opening of the first railway it was generally recognized that a railroad must be to some extent a monopoly, because the service to be performed was of such a nature that the high-

est degree of efficiency would be attained and the convenience of the public would be best subserved by committing the work to but one carrier. It is worthy of remark that even at that early period in railroad history the future direction of the development of the system was clearly foreseen by at least one man.

In the words of Mr. Sterne:

I have in hand a speech delivered in the House of Commons by Mr. James Morrison on the 17th of May, 1836. Mr. Morrison was the A. T. Stewart of England, and died leaving a fortune of four or five million pounds sterling. He was a member of Parliament, and he told his associates, as early as 1836, that their maximum rates would be of no value, that the economies of railway transportation from decade to decade, and the improvement of railway transportation and the development of railway traffic, would make their maximum rates ridiculously high, and would be an excuse for extortion in individual instances. Indeed, the clear understanding which he had of the railway problem, as early as 1836, was absolutely marvelous. But no attention was paid to his recommendation; it was voted down. They recognize now, however, that Mr. Morrison was one of the few men who then foresaw the railway problems of the present as they are now developing.

The new questions raised by this discovery of the element of monopoly in railroad transportation were considered by a Parliamentary committee, of which Sir Robert Peel was a member, and which reported in 1840 that the method of competition which has been described was impracticable; that monopoly upon each line was inevitable, that a single management of each railway was expedient, and that these changed conditions made necessary the protection of the public interests, for the reason "that the interest of the companies was, to a certain extent only, that of the public." At the same time the committee expressed the belief that "an enlightened view of their own interests would always compel managers of railroads to have due regard to the general advantage of the public."

It was supposed that the principles of free trade would apply in the construction and operation of railroads, and it was quite naturally expected that this business would be subject to the same natural laws of competition that governed and regulated other commercial enterprises and operations.

While these theories held sway parallel lines were looked to as an effective means of regulation. Parliament encouraged the building of competing lines, and this policy brought on a period of great activity in railroad construction and speculation. But the effects of competition between different lines were not what had been anticipated, and attracted

so much attention that in 1844 another committee, headed by Mr. Gladstone, was appointed, which took under consideration the question of competition and management, and submitted in all five reports. The second report recommended the appointment by Parliament of private bill committees to examine into the propriety of proposed competing schemes, and the third expressed the following conclusions:

That the indefinite concessions made to the earlier companies had become unnecessary; that competition between railways would do more harm to the companies than good to the public; that the effect of monopoly upon the public directly and upon the railways indirectly ought to be guarded against, and that in authorizing new lines Parliament should reserve certain powers to be exercised after a time.

The idea of state ownership as an effective means of regulation captivated this committee, which became convinced that the people must in one way or another pay for whatever transportation facilities they enjoyed, and that the main question was how to secure by legislation "the greatest amount of accommodation at the least cost." And the general conclusion reached by the committee in its final report was that regulation was to be depended upon rather than competition. These reports led to the passage in 1844 of a law looking to the ultimate acquisition of the railways by the Government, and prescribing the terms of their purchase at the expiration of twenty-one years should that policy be decided upon.

During this interval another unexpected characteristic of railway management came prominently into notice. The addition of too many competing lines developed a tendency toward amalgamation, and verified George Stephenson's axiomatic statement that "Where combination is possible, competition is impossible." Accordingly, in a report made by the Board of Trade of the United Kingdom relative to the numerous amalgamations proposed in 1845, it was recommended that amalgamations should not be permitted by Parliament when the purpose was to avoid competition, but only between branches and main lines or when continuous lines were formed, and then only after due consideration.

Another committee, appointed in 1846, discovered that where amalgamations had not been authorized the roads often reached the same end through private working arrangements, some of which virtually amounted to consolidation, and that they avoided competition wherever practicable. On the recommendation of this committee that it was necessary to establish a department of the Government to take "supervision of the railways and canals, with full power to enforce such

regulations as may from time to time appear indispensable for the accommodation and general interests of the public," the railway commission was created, but was only allowed to exist until 1851, when its duties were transferred to the Board of Trade. Meantime the efforts at amalgamation grew more and more determined, and the process went on by the consent of Parliament, notwithstanding all the restrictions imposed upon it, and despite the growing public dread of its effects.

Still another committee inquired into this vexed question of amalgamation, and its elaborate reports upon the subject brought about the passage of the "canal and railway traffic act" of 1854, usually known as the Cardwell act, which has been the model of much of our State legislation against unjust discrimination. The purpose of the act was to prevent undue preferences, and to compel interchange of traffic between railways and between railways and canals upon equal terms. This act established two important principles that have since been generally followed. One was that every company should be compelled to afford the public the full advantages of the convenient interchange of traffic from one line to another. The second was that the companies were under obligations to and should be required to make equal rates to all under the same circumstances.

The time when the state could take possession of the roads came in 1865, and a royal commission was appointed, which gathered a great deal of evidence and went into the questions presented quite fully. The most important conclusions of the commission have been summarized as follows:

That it is not expedient for the Government to avail itself of its reserved right to purchase railways.

That Parliament should not interfere with the incorporation and financial affairs of railway companies, leaving such matters to be dealt with, under the "joint stock companies act," limiting its own action to regulating the construction of the lines and the relations between the public and the companies so incorporated.

That railway companies should be bound to run at least two trains a day for third-class passengers.

That it would be "inexpedient, even if it were practicable, to adopt any legislation which would abolish the freedom which railway companies enjoy of charging what sum they deem expedient within their maximum rates, when properly defined, limited as that freedom is by the traffic act."

That railway companies should be required to make stated reports to the Board of Trade in such form as the board may require.

Finally in 1872, a joint select committee was appointed and made a most thorough investigation of the railroad question. The report of this

committee passed in review the history of England's legislation during its experience of forty years. It was shown that little had been accomplished, although thirty-three hundred acts had been passed and an expenditure of some £80,000,000 had been imposed upon the companies. It was also shown that the process of amalgamation had gone on with little regard to the recommendations of committees, commissions, and Government departments, and the result was that "while committees and commissions carefully chosen have, for the last thirty years, clung to one form of competition after another, it has, nevertheless, become more and more evident that competition must fail to do for railways what it does for ordinary trade; and that no means have yet been devised by which competition can be permanently maintained." Nor did the committee see any reason "to suppose that the progress of combination has ceased, or that it will cease until Great Britain is divided between a small number of great companies." At the same time, however, the committee made it evident that in the past amalgamation "had not brought with it the evils that were anticipated, but that in any event long and varied experience had fully demonstrated the fact that while Parliament might hinder and thwart, it could not prevent it, and it was equally powerless to lay down any general rules determining its limits or character."

Other important conclusions were reached by the committee as follows:

That competition between railways existed only to a limited extent and could not be maintained by legislation.

That combination was increasing and likely to increase.

That competition by sea should be secured by preventing railway companies from getting control over public harbors.

That canals were of advantage in securing competition; that their facilities for through shipments should be increased, and that no canal should be placed directly or indirectly under the control of any railway company.

That a system of equal mileage rates, or charges in proportion to distance, was inexpedient and impracticable for the following reasons:

(*a*) It would prevent railway companies from lowering their fares and rates, so as to compete with traffic by sea, by canal, or by shorter or otherwise cheaper railways, and would thus deprive the public of the benefit of competition, and the company of a legitimate source of profit.

(*b*) It would prevent railway companies from making perfectly fair arrangements for carrying at a lower rate than usual goods brought in larger and constant quantities, or for carrying for long distances at a lower rate than for short distances.

(*c*) It would compel a company to carry for the same rate over a

line which has been very expensive in construction, or which, from gradients or otherwise, is very expensive in working, at the same rate at which it carries over less expensive lines.

In short, to impose equal mileage on the companies would be to deprive the public of the benefit of much of the competition which now exists, or has existed, to raise the charges on the public in many cases where the companies now find it to their interest to lower them, and to perpetuate monopolies in carriage, trade, and manufacture in favor of those rates and places which are nearest or least expensive, where the varying charges of the companies now create competition. And it will be found that the supporters of equal mileage, when pressed, often really mean, not that the rates that they pay themselves are too high, but that the rates that others pay are too low.

Pressed by these difficulties, the proposers of equal mileage have admitted that there must be numerous exceptions, *e. g.*, where there is sea competition (*i. e.*, at about three-fifths of the railway stations of the United Kingdom), where low rates for long distances will bring a profit, or where the article carried at low rates is a necessary, such as coal. It is scarcely necessary to observe that such exceptions as these, while inadequate to meet all the various cases, destroy the value of "equal mileage" as a principle, or the possibility of applying it as a general rule.

That the fixing of legal rates based upon the actual cost of the railways and calculated to yield only a fair return upon such cost was impracticable.

That the plan of maximum charges had been a failure, and that such rates afforded little real protection to the public, since they were always fixed so high that sooner or later it became the interest of the companies to carry at lower rates.

That there should be publicity of rates and tolls.

That the new tribunal was needed to take supervision of the transportation interests of the Kingdom, and with authority to enforce the laws relating to railways and canals, to hear complaints and adjust differences, and to advise Parliament upon questions of railway legislation.

This investigation, by making plain the lessons taught by many years of experience, was especially valuable in at least bringing about a general recognition of the fact that the relations between the railways and the community require special treatment and cannot be defined or governed in accordance with the natural laws regulating ordinary commercial intercourse. It was evident that the policy adopted by the committee, if followed out to its conclusion, might lead in time to a few great corporations obtaining an absolute monopoly of the business of transportation by rail throughout the entire Kingdom, and even to finally placing the control of these most important interests in the hands of a small number of individuals, whose powers might become greater than those of the Government itself. Nevertheless, without being able to indicate how the relations between the Government and these great monopolies would or should ultimately be adjusted, the com-

mittee did not appear to believe that the time was ripe to check the development of the railway system of Great Britain by extreme measures, and was content to recommend the establishment of a special tribunal as the first step to be taken in inaugurating the policy of special treatment which it had become apparent must be adopted to meet the exigencies of the situation.

This recommendation was complied with by the creation of what is known as the railway commission of 1873, which was at first given a tenure of but five years, but which has since been continued. This tribunal is chiefly judicial in character; it is, in fact, a separate railway court, composed of three commissioners or judges, and has jurisdiction over all matters in relation to the interchange of traffic, and to all contracts between railway companies, as well as complaints of undue preference and of other violations of railway laws. The most recent official declaration concerning this commission is found in the report of the select committee of twenty-seven members, appointed by the House of Commons, in 1882, to inquire into its working and the rates charged by railways and canals. After an investigation, lasting several months, this committee reported that the tribunal should be made permanent as well as special, and say:

The railway commission has, to a great extent, been hindered in its work by the temporary character with which it has hitherto been invested. At the same time your committee are convinced that the establishment of the commission has been of great public advantage, not merely in causing justice to be speedily done in those cases which have been brought before it, but also in preventing differences from arising as between railway companies and the public. Its utility is not to be measured solely by the instances in which it has been called upon to "hear and determine," but also by the deterrent and controlling influence of its existence.

Representatives of the railway companies, backed up by legal gentlemen of eminence, have urged upon your committee that it is not desirable to continue the special tribunal in its present form, but that the court should be reconstituted by the appointment of a single judge, to be selected from the bench or the bar, aided by assessors wherever other than legal knowledge is required. From the traders and the general public, on the other hand, no demand has come for such a change; on the contrary, the general tenor of their evidence exhibits satisfaction with the services rendered to the public by the existing railway commission.

Accordingly the committee recommended:

That the railway commission be made permanent, and a court of record.

That the powers and jurisdiction of the railway commission be extended to cover—

(*a*) All questions arising under the special acts or the public statutes for regulating railway or canal traffic affecting passengers or goods.

(*b*) The making of orders which may necessitate the co-operation of two or more railway or canal companies within the statutory obligations of the companies.

(*c*) Power to order through rates on the application of traders, but no such order to impose on a railway company a rate lower than the lowest rate of such railway company for similar articles under similar circumstances.

(*d*) The revision of traffic agreements both of railways and canals, in as large a measure as the powers formerly exercised by the Board of Trade.

(*e*) The granting of damages and redress for illegal charges and undue preferences.

(*f*) The commissioners to have power, on the joint application of parties, to act as referees in rating appeals.

That the railway commissioners should deliver separate judgments when not unanimous.

One appeal to be granted as of right from the judgments of the commission, and "prohibition" as well as "*certiorari*" to be forbidden.

In conclusion, the committee "report that on the whole of the evidence they acquit the railway companies of any grave dereliction of their duty to the public. It is remarkable that no witnesses have appeared to complain of 'preferences' given to individuals by railway companies as acts of private favor or partiality, such as were more or less frequent during the years immediately preceding the act of 1854. Your committee find that the rates for merchandise on the railways of the United Kingdom are, in the main, considerably below the maxima authorized by Parliament, although these charges appear to be higher for the longer distances than on many continental lines. But on the other hand, the service of our home railways is performed much more rapidly than on the continent."

For later and more complete information concerning the English Railway Commission than could elsewhere be obtained the committee is indebted to the recently published work on "Railroad Transportation," by Mr. Arthur T. Hadley, of New Haven, who has made a very careful study of the English railway system and legislation. The results of his investigations are herewith presented in condensed form. He states the general situation as to legislation in the following paragraphs:

With the act of 1873 the general railroad legislation may be said to have closed. The movements which the public had feared for thirty years had now pretty much expended their force. Amalgamations

which were confidently expected in 1872 did not take place after all. Joint-purse arrangements became less important instead of more important, because railroads found that they could maintain rates without them.

It is not exactly true to say that "in Great Britain the discussion of the railroad problem may be considered as over for the time being." The railroad problem has ceased to be a bugbear; but it has become all the more a question for practical discussion. Vague fears with regard to the growth of the railway power have given place to pointed complaints as to its abuse in individual instances. The period of general legislation has passed. Mr. Adams is right in saying, "As a result of forty years of experiment and agitation Great Britain has on this head come back very nearly to its point of commencement." He is not quite right in adding, "It has settled down on the doctrine of *laissez-faire.*" It might better be said that it has settled down on the policy of specific laws for specific troubles.

After briefly mentioning the three experiments in the line of railway commissions attempted in England, in 1840, 1844, and 1846, Mr. Hadley says:

We have seen what were the events which led to the passage of the regulation of railways act in 1873. The commission appointed under that act was to consist of three members; one of them a railroad man, one a lawyer. They received a salary of £3,000 each. They were to decide all questions arising under the act of 1854, and subsequent acts connected with it. They were further empowered to arbitrate between railroads in a variety of cases; to compel companies to make through rates which should conform to the intention of the act of 1854; to secure publicity of rates; to decide what constitutes a proper terminal charge, and some other less important matters. On questions of fact their decision was to be final; on questions of law it was to be subject to appeal. The railway commissioners themselves were to determine what were questions of fact and what were questions of law. Subsequent acts have made but slight changes in these powers.

The commission consisted of able men—Sir Frederick Peel, Mr. Price, formerly of the Midland Railway, and Mr. Macnamara; the last-named died in 1877, and was succeeded by Mr. A. E. Miller. They went to work with energy, and in a spirit which promised to make the experiment a signal success. And it was at first supposed to be such a success. People judged by the reports of the commission itself; and they were the more prone to believe these reports because it was so desirable to find an easy solution of perplexing questions of railroad policy. Mr. Adams, writing in 1878, said, "The mere fact that the tribunal is there; that a machinery does exist for the prompt and final decision of that class of questions, puts an end to them. They no longer exist." That represented the general public opinion on the subject at the time; it represents the general impression in America down to the present time.

In 1878, the very year when Mr. Adams wrote, the original term of the commission expired. People supposed that it would be made

permanent. Instead of that the renewals have been for much shorter periods, leaving the commissioners a precarious tenure, and showing dissatisfaction somewhere.

A Parliamentary investigation on railroad rates in 1881-'82 showed the grounds of dissatisfaction only too clearly. The testimony revealed a state of things almost unsuspected by the general public, and giving an entirely different explanation of the fact that the commissioners had so few cases to deal with. The substance is that the power of the commission satisfies nobody. It has power enough to annoy the railroads, and not power enough to help the public efficiently.

The railway commission was a court, not an executive body, but to all intents and purposes a court of law. And in establishing this new court, in addition to those already existing, Parliament had two ends in view: (1) To have a tribunal which would and could act when others would or could not. (2) To avoid the expense, delay, and vexation incident to litigation under the old system. Neither end was well fulfilled.

(1) The commission could not act, partly from want of jurisdiction, partly from want of executive power. Its jurisdiction did not cover by any means the whole ground. The provisions about terminals, arbitration, working agreements, etc., amounted to very little. Its real power was under the act of 1854. It could under this act require companies to furnish "proper facilities," and it could prevent their giving "preferences." But it could *not* compel a company to comply with special acts or special provisions of its charter. This is a serious difficulty, because the question of proper facilities was closely connected with charter requirements, and the railroad could almost anywhere raise the point of want of jurisdiction.

Nor could it enforce its decrees. Passive resistance of the railroads and jealousy on the part of the old established courts combined to produce this effect. For instance, under the act of 1854, if the railways refused to comply with the decisions of the court of common pleas, they were liable to a fine of $1,000 for every day's delay. The London, Chatham and Dover Railway refused to comply with one of the commission's decisions, and claimed that they were not liable to any such fine, although all the powers of the court of common pleas, under the act of 1854, had been transferred to the railway commission by the act of 1873. The court of exchequer actually sustained the railroad; and it was not until 1878 that by a decision of the Queen's bench the railway commission really had the power to do anything if a company chose to disregard its orders.

The injunctions of the commission, at best, only affect the future; for any remedy for the past there must be a new complaint and trial before a regular court. And so it often happens that a railroad, after exhausting all its means of resistance, obeys the decisions of the commission in reference to one particular station, without taking any notice of it at other stations where the same principle is involved. Thus, in the case of the manure traffic of Aberdeen, after long litigation, the rate was decided to be illegal. The railroad then reduced its Aberdeen rates, but continued its old schedule of charges at other points on its route

where there were not organized interests strong enough to make a fight.

On the face of the act of 1873 the decisions of the commission, as to what were questions of fact or questions of law, appeared to be final. But by writ of mandamus from a court of appeal the decision on this point could be at once taken out of the hands of the commission by compelling them "to state a case," which could then be made the subject of action in the higher court. So this important power was made of no effect.

(2) Complaints before the commission are not quite so slow or costly as they were before the courts, but they are bad enough to prevent most men from undertaking them. Sir Frederick Peel himself admits that the expense frightens people away from making complaints. But this is by no means the worst. The testimony before the Parliamentary committee of 1881-'82 is full of matter to startle those who argue that because there are few complaints before the commission there are few men that have grievances. Men have good reason to think twice before they enter a complaint.

In the Aberdeen manure case, already referred to, the Aberdeen men, successful at every point, lost more money than they gained. Every important case is so persistently appealed that the original promptness or cheapness of railway commission practice counts for nothing. But the indirect results are yet worse. A complainant is a marked man, and the commission cannot protect him against the vengeance of the railroads. A town fares no better. It complains of high terminal charges, and the company retorts by raising the local tariff for that place 100 per cent. A coal mine complains of freight rates, and the company refuses to carry for it on any terms; it has ceased, it says, to be a common carrier of coal. Even the war department is afraid. It has grievances, but it dare not make them public for fear of reprisals. "It is quite clear," says the secretary of the Board of Trade, "that it is a very formidable thing to fight a railway company."

It is not easy to see what can be done in the face of these difficulties, so different from anything which we see in most American States. Our commissioners, with fewer powers, have infinitely more power. The reason is, that in America to defy such an authority involves untold dangers, public sentiment being irritable and unrestrained, whereas in England it involves no danger at all, public sentiment being long-suffering and conservative.

The lawyers say, strengthen the legal element in the commission. Some of the railroad men say so too, because they think that a commission formed on the model of the old courts would interfere no more than the old courts. On the other hand, many men desire the appointment of a public prosecutor to relieve individuals of the danger and odium of bringing complaints, or that chambers of commerce may be allowed to undertake such prosecutions. Others go still further and urge that the powers of the commission be increased, and that they be allowed to determine on general grounds what constitutes a reasonable rate. The commission itself would be glad to do that, but such a thing, however cautiously carried out, would involve the granger principle of fixing rates. It seems unlikely that Parliament will make any of these

proposed changes, except to give chambers of commerce the right to prefer charges.

We have dwelt on the dark side of the picture, because there is a general impression in this country that the English railway commission is a complete success. It must not be inferred that it is a complete failure. It has in the first nine years of its existence passed judgment on one hundred and ten cases. Only seventeen of these have been appealed, and in eleven of them the commissioners have been sustained. The decisions have, as a rule, been marked by good sense and impartiality. The direct good to the complainants may have been small, but the indirect good to the public was, doubtless, great. The commission has made serious and generally successful efforts to enforce a law in cases where it would otherwise have been a dead letter. These particular cases may have given more trouble than they were worth. But the very existence of such a power constitutes a check upon arbitrary action in general. We cannot assume, as many do, that the few complaints preferred before the commission represent anything like the amount of well-founded grievances. But we can assume that the chance for such complaints to be made and heeded makes the railroad managers more cautious in giving occasion for them. Although no one is fully satisfied with what the commission has done, the great majority of shippers are obviously of the opinion that it has prevented much evil which would otherwise have gone unchecked.

In concluding his sketch of the English railroad legislation, Mr. Hadley shows that the system of special rates to develop business has grown up in the same way as in America; that the chief source of public complaint is not extortionate rates, but different rates; that the low through rates are occasioned by the competition of water routes, which has existed at three-fifths of the stations in the United Kingdom; that the railroads have been obtaining control of the canals, and even of the open water routes in some cases, by securing possession of the landing places and harbor facilities, but are unable to control the water routes between London and foreign countries; that while the courts have succeeded in almost entirely stopping discriminations between individuals, personal favoritism, and the payment of rebates, the discriminations against localities and certain lines of business have become more conspicuous; and he sums up the present state of things, as follows:

(1) The roads may make what special rates they please; but if they make a rate to one man they must extend the same privilege to all others in like circumstances. If they have been secretly paying rebates to one shipper, they may be compelled to refund to any other shipper similarly placed the same rebates on all his shipments since the special contract with the one shipper began.

(2) It is held by the railway commissioners that two shippers are similarly placed and must be similarly treated when the cost to the railroad of handling the goods for one is the same as for the other; and, conversely, unless some special reason can be shown, the railroad has no

right to put a less favorably situated shipper on an equality with a more favorably situated one.

(3) But the last Parliamentary committee has refused to indorse these principles, and has said that a preference is not unjust so long as it is the natural result of fair competition.

THE NECESSITY OF NATIONAL REGULATION OF INTERSTATE COMMERCE

The two propositions which the committee has kept prominently in view throughout the entire investigation have been whether any legislation for the regulation of interstate transportation is necessary or expedient, and, if so, in what manner can the public interest be best subserved by legislation on that subject.

The consideration of the first proposition may seem to be a work of supererogation, for it is the deliberate judgment of the committee that upon no public question are the people so nearly unanimous as upon the proposition that Congress should undertake in some way the regulation of interstate commerce. Omitting those who speak for the railroad interests, there is practically no difference of opinion as to the necessity and importance of such action by Congress, and this is fully substantiated by the testimony accompanying this report, which is a fair concensus of public sentiment upon the question. The committee has found among the leading representatives of the railroad interests an increasing readiness to accept the aid of Congress in working out the solution of the railroad problem which has obstinately baffled all their efforts, and not a few of the ablest railroad men in the country seem disposed to look to the intervention of Congress as promising to afford the best means of ultimately securing a more equitable and satisfactory adjustment of the relations of the transportation interests to the community than they themselves have been able to bring about.

The evidence upon this point is so conclusive that the committee has no hesitation in declaring that prompt action by Congress upon this important subject is almost unanimously demanded by public sentiment.

This demand is occasioned by the existence of acknowledged evils incident to and growing out of the complicated business of transportation as now conducted, evils which the people believe can be checked and mitigated, if not wholly remedied, by appropriate legislation. The committee recognizes the justice of this demand, and believes that action by Congress looking to the regulation of interstate transportation is necessary and expedient, for the following reasons:

1. The public interest demands regulation of the business of

transportation because, in the absence of such regulation, the carrier is practically and actually the sole and final arbiter upon all disputed questions that arise between shipper and carrier as to whether rates are reasonable or unjust discrimination has been practiced.

It is argued by railroad representatives that arbitrary or oppressive rates cannot be maintained; that they are adjusted and sufficiently regulated by competition with rival roads and with water routes, by commercial necessities, by the natural laws of trade, and by that self-interest which compels the corporations to have due regard to the wants and the opinions of those upon whom they must depend for business; that such discriminations as exist are for the most part unavoidable; that the owners and managers of the property are the best judges of the conditions and circumstances that affect the cost of transportation and should determine the compensation they are entitled to receive; and that, in any event, the common law affords the shipper an adequate remedy and protection against abuse or any infringement of his rights.

This answer fails to recognize the public nature and obligations of the carrier, and the right of the people, through the Governmental authority, to have a voice in the management of a corporation which performs a public function. Nor do the facts warrant the claim that competition and self-interest can be relied upon to secure the shipper against abuse and unjust discrimination, or that he has an available and satisfactory remedy at common law.

If it is found that the common law and the courts do not, in fact, afford to the shipper an effective remedy for his grievances, we have no need to inquire to what extent grievances may exist. The complicated nature of countless transactions incident to the business of transportation make it inevitable that disagreements should arise between the parties in interest, and it is neither just nor proper that disputed questions materially affecting the business operations of a shipper should be left to the final determination of those representing an opposing financial interest. When such disagreements occur the shipper and the carrier are alike entitled to a fair and impartial determination of the matters at issue, and by all the principles governing judicial proceedings the most fair-minded railroad official is disqualified by his personal interest in the result from giving such a determination. If, however, there existed an impartial tribunal to which the shipper could readily appeal, he would find less occasion for appealing from the decision of the carrier, and the differences between shipper and carrier would be more likely to be adjusted amicably without such an appeal.

The simple fact that the shipper is now obliged to submit to the adjudication of his complaint by the other party in interest, the party by whom he supposes himself to have been aggrieved, is in itself sufficient to demonstrate the necessity of such legislation as will secure to the shipper that impartial hearing of his complaints to which he is entitled by all the recognized principles of justice and equity.

Evidence is not wanting to prove that the remedy at common law is impracticable and of little advantage to the ordinary shipper. It has been found so by the people of the States in dealing with their local traffic, and, as has been shown, their recognition of the fact has been authoritatively recorded in nearly every State in the Union by statutory enactments, and in many of them by the establishment of commissions, in the effort to provide for the shipper that prompt and effective remedy which it has been found by experience that recourse to the common law has failed to afford. The reasons for this failure apply with even greater force to the more complicated transactions of interstate commerce than to State traffic, because the former involve more perplexing questions and are affected by a greater diversity of varying conditions. The legislation of the States, the reports of the State commissions, the records of the courts, the evidence of shippers, and, in short, the whole current of testimony, is to the same effect; and the fact stated is also admitted by some of the highest railroad authorities. Mr. Fink says:

> In many cases where small amounts are involved, which do not justify legal proceedings against the company, the aggrieved parties are prevented from prosecuting their claims. * * * Ordinary courts are not properly constituted for that purpose, and the time required for the adjudication of claims is so long and the expense so great as to defeat the very object for which proceedings are instituted.

Leaving out of consideration the natural disinclination of the average shipper to engage in litigation with a corporation which may have the power to determine his success or failure in business, and to enter the lists against an adversary with ample resources and the best legal talent at its command and able to wear out an opponent by the tedious delays of the law, it is plain that the shipper is still at a great disadvantage in seeking redress for grievances under the common law, which places upon the complainant the burden of proof and requires him to affirmatively establish the unreasonableness of a given rate or the fact of an alleged discrimination. What such an undertaking practically involves is indicated by the following extract from the statement of Mr. Kernan, the chairman of the New York commission, which sums up the whole case:

Assuredly there have been and do exist unreasonable rates and unjust discriminations. This much will be admitted by all; it will not be denied even by any carrier. Why, then, have not the courts enjoined the continuance of the wrongs and enforced the payment of damages? Why, again, is it that substantially no suits ever have been brought and that so few decisions in this country exist? It is not because of defects in the law or in the constitution of the courts, but it is because the subject is one which neither client nor lawyer, judge nor jury, can unravel or deal with intelligently within the compass of an ordinary trial and with such knowledge of the matter as men generally well educated possess. Let a man take the testimony in five volumes before the Hepburn committee; read one hundred pages of the clear and able statements of Mr. Blanchard, for instance; con over the facts and figures he gives, and then let him try to reach a conclusion upon the question under discussion. Some conception will thus be obtained of what a lawsuit is which involves the reasonableness of rates, or the existence of an unjust discrimination, or a local rate as compared with a through rate. As the onus is upon the complainant, add to his difficulties the fact that his adversary has nearly all the evidence in his possession, locked up in books and in the memory and intelligence of experts who have made the subject their study. The expense involved, the uncertainty to be faced, and the difficulties to be overcome in an ordinary suit at law have made that remedy obsolete and useless.

All these considerations, fully corroborated as they are by the evidence submitted, have satisfied the committee that the common law wholly fails to afford an effective remedy against unreasonable or discriminating rates, and that, without additional legislation, the carrier is practically the sole and only judge of the rights of the producer and shipper in respect to transportation.

2. It is the duty of Congress to undertake the regulation of the business of transportation, because of admitted abuses in its management and of acknowledged discriminations between persons and places in its practical operation—evils which it is possible to reach and remedy only through the exercise of the powers granted by the Constitution to Congress, and against which the citizen is entitled to the protection and relief the national authority can alone afford.

Attention will be called hereafter to these causes of complaint; and it is perhaps only necessary to suggest here that the railroad argument against legislation on the ground that competition, the laws of trade, and an "enlightened self-interest" afford all needful protection and the most effective regulation, is predicated upon the conditions which prevail at the great commercial centers and in favored localities where competition is most active, and applies more particularly to the larger shippers, who are always able to take care of themselves and at such

points can usually depend for protection and fair treatment upon the eagerness of the corporations to capture all the business possible. But it should be the aim of the law to protect the weak, and it is at the great number of non-competitive interior points, scattered all over the land, at which even the protection elsewhere afforded by competitive influences is not found, and where the producer and shipper are most completely in the power of the railroads, that additional safeguards are most needed.

3. National legislation is necessary to remedy the evils complained of, because the operations of the transportation system are, for the most part, beyond the jurisdiction of the States, and, until Congress acts, not subject to any governmental control in the public interest.

The States have no power to regulate interstate commerce, and it appears from the evidence that even their control of their own domestic traffic is restricted and frequently made inoperative by reason of its intimate intermingling with interstate commerce and by the present freedom of the latter from any legislative restrictions. Some of the difficulties of effective State regulation in the absence of national legislation have been pointed out elsewhere in this report, and illustrations have been given of the greater volume and importance of interstate as compared with State traffic. National supervision would supplement, give direction to, and render effective State supervision, and is especially necessary as the only method of securing that uniformity of regulation and operation which the transportation system requires for its highest development.

The clearly-established fact that, by reason of the constitutional division of powers between the States and the General Government, the States have been able only to partially control the business of transportation within their own borders has been the principal inciting cause of the popular demand for national regulation, and is sufficient, in the judgment of the committee, to call for such action by Congress as will make effective the means of regulation found necessary and adopted by the States.

4. National legislation is also necessary, because the business of transportation is essentially of a nature which requires that uniform system and method of regulation which the national authority can alone prescribe.

The key-note to all the decisions of the United States Supreme Court concerning the power to regulate commerce is found in the declaration made in Cooley *v.* Board of Wardens, and frequently

referred to in other cases, that "whatever subjects of this power are in their nature national, or admit only of one uniform system or plan of regulation, may justly be said to be of such a nature as to require exclusive legislation by Congress;" and, as is said by the court in the late case of Gloucester Ferry Company *v.* Pennsylvania, "it needs no argument to show that the commerce with foreign nations and between the States, which consists in the transportation of persons and property between them, is a subject of national character, and requires uniformity of regulation. Congress alone, therefore, can deal with such transportation."

5. The failure of Congress to act is an excuse for the attempts made by the railroads to regulate the commerce of the country in their own way and in their own interests by whatever combinations and methods they are able to put into operation.

Through the absence of national legislation the railroads of the United States have been left to work out their own salvation. The practical results of their efforts have been by no means encouraging, as the present depressed condition of the railway interests bears witness, nor do they claim to have made any substantial progress during the past fifteen or twenty years. It is true that in this period the railroads have accomplished wonders in reducing the cost of transportation, in removing the limitations of distance from trade between remote localities, and in building up and widely extending the general commerce of the country. But, notwithstanding all these marvelous achievements, for which due credit should be given, the solid fact still claims consideration, that the inequalities and discriminations which characterize the operations of the system in its entirety are now as pronounced as in the earlier stages of its development.

In the recognized existence of these evils and in the failure of the national authority to offer any remedy, railroad managers have found their justification for seeking a remedy through methods which have not commended themselves to the public judgment and which have threatened even greater dangers to the body-politic. In the absence of national legislation, the railroads have naturally resorted to the only methods by which they could unaided secure any degree of stability and uniformity in their charges—consolidations and confederation. The final outcome of continued consolidation would be the creation of an organization more powerful than the Government itself and perhaps beyond its control. The same result might follow the successful develop-

ment of the policy of confederation or pooling, if unrestricted by Governmental supervision, and either would be inimical to the public interest. But while this would be the logical outcome of the existing tendency of railway organization and management, there are satisfactory reasons for believing that it will not be the actual result, and that this policy has substantially reached the limit to which it can be carried. In a sense it may be true that the railroad properties of the country are to-day largely within the control of a comparatively small circle, yet the colossal combinations which have been effected find other gigantic combinations equally as powerful successfully contending for the traffic of the territory they seek to control. The vast geographical extent of the country, its immense resources, the diverse interests of different sections, the abundance of capital, the commanding influence and the enterprise of the great commercial centers, the impossibility of controlling 35,000 miles of free water-routes—all these considerations lessen the dangers to be apprehended from future consolidations and combinations, and at the same time show how difficult it will be for the railroads to work out the problem alone and unaided.

Experience and investigation have up to this time failed to indicate how the inequalities and discriminations complained of, which have grown into and become a fundamental part of the system upon which the business of the entire country is conducted, are to be done away with without a serious disturbance of every individual and public business interest. To equalize through and local rates, and to give them that degree of uniformity and stability so greatly needed, must necessarily involve a complete readjustment and reconstruction of the commercial relations and business methods of the whole country. How this is to be accomplished is the secret which underlies the satisfactory solution of the railroad problem.

That a problem of such magnitude, importance, and intricacy can be summarily solved by any master-stroke of legislative wisdom is beyond the bounds of reasonable belief. That the railroads, unaided or unrestrained, can or will eventually work out its solution seems highly improbable, judging from past experience, and cannot reasonably be expected. That a satisfactory solution of the problem can ever be secured without the aid of wise legislation the committee does not believe.

THE CAUSES OF COMPLAINT AGAINST THE RAILROAD SYSTEM.

The complaints against the railroad system of the United States expressed to the committee are based upon the following charges:

1. That local rates are unreasonably high, compared with through rates.

2. That both local and through rates are unreasonably high at non-competing points, either from the absence of competition or in consequence of pooling agreements that restrict its operation.

3. That rates are established without apparent regard to the actual cost of the service performed, and are based largely on "what the traffic will bear."

4. That unjustifiable discriminations are constantly made between individuals in the rates charged for like service under similar circumstances.

5. That improper discriminations are constantly made between articles of freight and branches of business of a like character, and between different quantities of the same class of freight.

6. That unreasonable discriminations are made between localities similarly situated.

7. That the effect of the prevailing policy of railroad management is by an elaborate system of secret special rates, rebates, drawbacks, and concessions, to foster monopoly, to enrich favored shippers, and to prevent free competition in many lines of trade in which the item of transportation is an important factor.

8. That such favoritism and secrecy introduce an element of uncertainty into legitimate business that greatly retards the development of our industries and commerce.

9. That the secret cutting of rates and the sudden fluctuations that constantly take place are demoralizing to all business except that of a purely speculative character, and frequently occasion great injustice and heavy losses.

10. That, in the absence of national and uniform legislation, the railroads are able by various devices to avoid their responsibility as carriers, especially on shipments over more than one road, or from one State to another, and that shippers find great difficulty in recovering damages for the loss of property or for injury thereto.

11. That railroads refuse to be bound by their own contracts, and arbitrarily collect large sums in the shape of overcharges in addition to the rates agreed upon at the time of shipment.

12. That railroads often refuse to recognize or be responsible for the acts of dishonest agents acting under their authority.

13. That the common law fails to afford a remedy for such grievances, and that in cases of dispute the shipper is compelled to submit to the decision of the railroad manager or pool commissioner, or run the risk of incurring further losses by greater discriminations.

14. That the differences in the classifications in use in various parts of the country, and sometimes for shipments over the same roads in different directions, are a fruitful source of misunderstandings, and are often made a means of extortion.

15. That a privileged class is created by the granting of passes, and that the cost of the passenger service is largely increased by the extent of this abuse.

16. That the capitalization and bonded indebtedness of the roads largely exceed the actual cost of their construction or their present value, and that unreasonable rates are charged in the effort to pay dividends on watered stock and interest on bonds improperly issued.

17. That railroad corporations have improperly engaged in lines of business entirely distinct from that of transportation, and that undue advantages have been afforded to business enterprises in which railroad officials were interested.

18. That the management of railroad business is extravagant and wasteful, and that a needless tax is imposed upon the shipping and traveling public by the unnecessary expenditure of large sums in the maintenance of a costly force of agents engaged in a reckless strife for competitive business.

THE ESSENCE OF THE COMPLAINTS

It will be observed that the most important, and in fact nearly all, of the foregoing complaints are based upon the practice of discrimination in one form or another. This is the principal cause of complaint against the management and operation of the transportation system of the United States, and gives rise to the question of greatest difficulty in the regulation of interstate commerce.

It is substantially agreed by all parties in interest that the great desideratum is to secure equality, so far as practicable, in the facilities for transportation afforded and the rates charged by the instrumentalities of commerce. The burden of complaint is against unfair differences in these particulars as between different places, persons, and commodities, and its essence is that these differences are unjust in comparison with the rates allowed or facilities afforded to other persons and places for a like service under similar circumstances.

The first question to be determined, apparently, is whether the inequalities complained of and admitted to exist are inevitable, or whether they are entirely the result of arbitrary and unnecessary discrimination on the part of the common carriers of the country; and the consideration of this question suggests an inquiry as to the proper basis upon which rates of transportation should be established.

A COMPARISON OF MUNICIPAL AND PRIVATE OWNERSHIP

BY THE COMMISSIONER OF LABOR, 1894

As stated in the preface, this report is designed to bring out the essential facts relating to private and municipal ownership of waterworks, gas works, and electric-light plants. By private ownership is meant ownership by individuals, companies, or private corporations, and by private plants is meant plants owned, controlled, and operated by such individuals, companies, or corporations. By municipal ownership is meant ownership by cities, towns, villages, etc., and by municipal plants is meant plants owned, controlled, and operated for the public account by such public corporations. It has not been intended to furnish the means whereby the details of business and the results of the operation of specific plants could be identified and any use made of such knowledge that might be prejudicial to the interests of such plants. It has rather been the intention of the Department to secure the fullest possible information in regard to the business and production of as large a number of such plants as could be canvassed in a reasonable time, aiming always to cover representative plants, and in a sufficient number to afford a reliable representation of the varying conditions found in these public utilities, both under private and under municipal ownership and control. The agitation of the subject of private and municipal ownership during the last few years quite naturally rendered the task of securing data from private corporations difficult. It was found necessary early in the investigation to make the specific statement that the names of plants would not be published in connection with the data furnished, or the city, town, or State in which located. Without this pledge by the Department the investigation could not have been prosecuted successfully, inasmuch as the greatest objection was constantly encountered to furnishing the details of private business if they were to be presented in such a manner as to enable particular plants to be identified. With this pledge it was found possible to secure reports from

quite a large proportion of the private water, gas, and electric-light plants in the United States, both large and small, thus furnishing data representative of every condition for purposes of comparison with similar plants operating under municipal ownership. It will readily be seen that for the purpose of statistical comparison the names and location of plants would add but little to the value of the figures given, while with the omission of such means of identification reliable figures could be secured relating to plants under private or corporate ownership and control.

As has been intimated, not all of the plants in the United States have been covered by the investigation. The Department pursued its usual course in the collection of the data, sending its special agents to the various plants throughout the country, and securing the data by their personal inspection of the plants and of the details of their business, the various facts being taken directly from the records of the plants so far as such were in existence. At the beginning of the investigation it was realized that it would be impossible to make a canvass of all of the plants in the country with the limited force at the disposal of the Department and present the facts while comparatively fresh. It was therefore determined to cover as great a number of the plants as possible within the time which could be devoted to the work. In no cases have leased plants, or plants established in factories, etc., for the sole use of the owner, been included. Quite a large proportion of both the private and municipal plants were canvassed, and it is believed that the data presented in the tables are fairly representative of the varying conditions found throughout the country.

The following table shows the total number of water, gas, and electric-light plants, private and municipal, in the United States, so far as could be ascertained; the number for which schedules were secured and which form the basis for this report; the total investment and the value of product in municipal water, gas, and electric-light plants in the United States, and the total investment and the value of product in the plants, both private and municipal, which are included in this report:

NUMBER OF, TOTAL INVESTMENT IN, AND VALUE OF PRODUCT IN, WATER, GAS, AND ELECTRIC-LIGHT PLANTS IN THE UNITED STATES.

	Waterworks.		Gas works.		Electric-light plants.	
	Private.	Municipal.	Private.	Municipal.	Private.	Municipal.
Number in the United States	1,539	1,787	951	14	2,572	460
Number included in this report	375	659	356	11	632	320
Per cent included in this report	24.37	36.88	37.43	78.57	24.57	69.57
Total investment in all plants in the United States	$267,752,468	$513,852,568	$330,346,274	$ 1,918,120	$265,181,920	$ 12,902,677
Total investment in plants included in this report	$116,710,833	463,574,312	152,669,792	1,395,373	113,917,815	10,908,929
Per cent of total investment represented by plants included in this report	43.59	90.22	46.22	72.75	42.96	84.55
Value of product in all plants in the United States	$ 25,665,669	$ 45,506,130	$ 73,446,133	$ 487,355	$ 56,490,652	$ 3,531,605
Value of product in plants included in this report	$ 11,416,186	42,508,490	33,938,262	431,672	24,267,460	2,909,199
Per cent of total value of product represented by plants included in this report	44.48	93.41	46.21	88.57	42.96	82.38

Of the 3,326 waterworks in the United States it was found that 46.27 per cent were owned and operated by private individuals, firms, and corporations, while 53.73 per cent were owned and operated by the cities, towns, and villages in which they were located; of the 965 gas works, 98.55 per cent were owned privately, while but 1.45 per cent were municipally owned; and of the 3,032 electric-light plants, 84.83 per cent were private and 15.17 per cent were municipal. As will be seen, this report covers 24.37 per cent of the private waterworks in the United States and 36.88 per cent of those under municipal ownership and control; 37.43 per cent of the private and 78.57 per cent of the municipal gas works, and 24.57 per cent of the private and 69.57 per cent of the municipal electric-light plants. Of the 1,539 privately owned waterworks, about 32 per cent were located in towns or villages which had less than 1,000 population at the census of 1890, while about 25 per cent of the 1,787 municipally owned plants were so located. Of the 951 privately owned gas works, about one-third of 1 per cent were located in towns and villages which had less than 1,000 population at the census of 1890, while of the municipally owned plants none were so located. So far as the electric-light plants are concerned, about 9 per cent of the 2,572 privately owned plants were located in towns and villages which had less than 1,000 population at the census of 1890, while about 9 per cent of the 460 municipally owned plants were so

located. About one-fourth of all the waterworks in the United States are located in small towns and villages, while a very small proportion of the gas works and about one-tenth of the electric-light plants are so located. Inquiry was made in regard to the waterworks located in these small towns and villages, and as a rule they were found to be of an unimportant and inexpensive character and were established largely for purposes of fire protection. No plants, water, gas, or electric-light, which are located in towns and villages which had less than 1,000 population at the census of 1890 have been included in the tables which are given in this report.

The table also furnishes a very close estimate of the total amount invested in municipal plants in the United States, based on returns directly from the plants. The municipal waterworks for which full data are included in this report represent 90.22 per cent of the total investment in such municipal works in the United States, the municipal gas works represent 72.75 per cent, and the municipal electric-light plants represent 84.55 per cent. So far as private works are concerned it was found necessary to secure this estimate as to total investment from various sources. Nevertheless, it is thought to be fairly accurate and shows that the private waterworks for which full data are included in this report represent 43.59 per cent of the total investment in such private works in the United States, that the private gas works represent 46.22 per cent, and that the private electric-light plants represent 42.96 per cent. In this connection it should be stated that the figures given as the investment represent the actual cost of the plants and the amounts expended on the same for extensions and betterments up to the end of the fiscal year for which reports were made.

This table also shows the value of the product during the fiscal year of the plants included in the report and an estimate of the total value of product for the year in all plants in the United States. From this it appears that 75.77 per cent of the total value of water, 46.49 per cent of the total value of gas, and 45.28 per cent of the total value of electricity produced by the whole number of the plants in the United States was produced by the plants for which full details are given in this report. The year covered is usually a fiscal year ending in 1898, although for some plants the year ends as far back as 1897. This is due to the necessary length of time which was devoted to the canvass by the agents of the Department, as the data were in every case secured cover-

ing the business of the last year for which complete information could be had at the time of the visit of the agent to the plant.

WATER WORKS

Salaries and Wages

As is seen by reference to Table VI, separate figures for salaries and wages have not been secured for all of the 1,034 plants covered, a portion or all of the wage cost being included in salaries in some plants and vice versa. For 326 private plants and 561 municipal plants, however, the accounts were kept separately and accurate data were obtained. The short table which follows is based on the plants reporting separately as to the cost of salaries and wages during their last fiscal year, and shows, for each of the groups adopted in the general tables, the average cost of salaries and wages per 1,000,000 gallons of water furnished for both private and public consumption.

AVERAGE COST OF SALARIES AND WAGES PER 1,000,000 GALLONS OF WATER FURNISHED.

Water furnished (gallons).	Private plants.			Municipal plants.		
	Number reporting.	Average cost per 1,000,000 gallons.		Number reporting.	Average cost per 1,000,000 gallons.	
		Salaries.	Wages.		Salaries	Wages.
Under 1,000,000	...	...	...	1	$34.25	$821.92
1,000,000 and under 5,000,000	3	$31.07	$41.26	17	36.72	120 63
5,000,000 and under 10,000,000	7	31.15	53.03	22	25.07	56.51
10,000,000 and under 15,000,000	7	42.33	48.25	29	14 40	39.70
15,000,000 and under 20,000,000	9	16.33	37.12	36	16.58	31.99
20,000,000 and under 25,000,000	8	19.99	43.83	23	12.42	23 19
25,000,000 and under 50,000,000	40	16.41	16.61	90	10 18	18.49
50,000,000 and under 75 000,000	38	11.94	11.28	46	6.12	13.70
75,000,000 and under 100,000,000	22	12.81	11 96	21	10.94	15 14
100,000,000 and under 125,000,000	18	11.12	9.52	22	4.91	12 00
125,000,000 and under 150,000,000	7	8.75	8.63	20	7.01	8.96
150,000,000 and under 175,000,000	14	10.22	7.97	5	3 00	4 60
175,000,000 and under 200,000,000	8	11 75	10.27	11	4.50	6.67
200,000,000 and under 250,000,000	22	8.63	9.22	12	7 66	8.33
250,000,000 and under 500,000,000	45	5.93	6.49	53	4.54	6.16
500,000,000 and under 750,000,000	30	5.14	4.78	37	4.03	8.42
750,000,000 and under 1,000,000,000	14	4.43	4.40	20	3.73	5 60
1,000,000,000 and under 5,000,000,000	30	3.90	3.89	77	2.57	4.92
5,000,000,000 and under 10,000,000,000	4	7.03	6.59	6	1.57	5.07
10,000,000,000 or over	...	...	...	13	1.87	3.74

The first two groups in the above table are made up of plants furnishing less than 5,000,000 gallons of water per year, and, as will be found later on, the municipal plants in these groups have little if any revenue from the sale of water to private users, being maintained

mainly for fire protection. As a consequence the salary and wage cost per 1,000,000 gallons as well as all other costs must necessarily be large. For this reason it may be well to exclude at least these two groups from consideration in using this table. Beginning with the group of plants furnishing 5,000,000 and under 10,000,000 gallons per year, it is seen that so far as salaries are concerned the average cost in the private plants is in excess of the average in the municipal plants, and in the next group this is also true, this cost in the private plants being almost three times that in the municipal plants. In the next group the average salary cost is almost the same in both kinds of plants, while in the remaining fourteen groups containing private plants this cost is larger in the private plants than in those under municipal ownership and control. As regards wage cost it is seen that in the group of plants furnishing 5,000,000 and under 10,000,000 gallons per year the average cost in the municipal plants exceeds that in the private plants, while in each of the next three groups this cost in the private plants is larger than in those municipally owned. In each of the next five groups, however, the average wage cost per 1,000,000 gallons during the year is larger in the municipal plants than in the private, while in each of the next four it is smaller. In each of the next three groups this average wage cost is smaller in the private plants, while in the last group affording comparison it is considerably smaller in the six municipal plants entering into the average than in the four private plants in this group.

Cost of Production

In this connection it has been deemed advisable to summarize the results as to cost of production and, accordingly, a table has been made, showing, for the private and municipal plants falling under each of the groups used in the general tables, the average cost of production during the year per 1,000 gallons of water furnished for private and public consumption. In order that these two classes of plants may be placed on the same basis in this table, two columns showing cost have been made for the plants under private or corporate ownership and control and two for those under municipal ownership and control. The first of these columns shows the average cost of production excluding depreciation, taxes, and interest on the total investment (cost of plant). Depreciation is to some extent a theoretical element, and for this reason some may wish to see the figures with this element excluded; taxes have

been excluded in the case of private plants and in the few cases where they appear as an actual charge in municipal plants, because taxes are not usually a cost in municipal plants; while interest on the total investment is excluded because of the fact that private or corporate owners do not usually borrow the funds for the investment and pay interest on the same, as is done by municipalities, but issue and sell stock for this purpose. Bonds, it is true, are also sometimes issued by private plants, and in such cases there is a regular interest charge; but the practice is far from uniform. With these elements eliminated in both classes of plants, only the actual costs for administration, labor, supplies, and repairs and renewals are taken into consideration. The second column showing cost for each of the two classes of plants, on the other hand, includes depreciation, taxes, and interest on the total investment (cost of works). Interest has in all cases been estimated at the rate paid by the city on its last issue of bonds. Private and municipal plants are thus put upon the same basis. The assumption of this rate as applied to private plants is justified by the probability that the municipality could raise funds for the establishment of such a plant at the rate paid upon its last issue of bonds, and that therefore for a fair comparison the same rate should be used for both classes of plants. Some private plants, it is true, will be found paying interest charges in excess of this estimate, because of the fact that bonds have been issued at a higher rate of interest or in excess of the cost of the plant. In the case of municipal plants the question may be raised as to why taxes are here shown. It is well understood that municipal plants seldom pay taxes, but in order to furnish a fair basis for comparison estimates have been inserted representing the taxes that would have been collected from these plants had they been owned by private individuals or corporations. It will be seen at once that plants owned and operated by municipalities take the place of just so much private property from which taxes would be received to the amount estimated, the ownership on the part of cities involving a definite decrease in the amount of taxable property. The estimates are based on the judgment of the local assessors as to the assessed value of the plants considered. The table giving the average cost of production per 1,000 gallons of water furnished, for both private and municipal plants, follows.

AVERAGE COST OF PRODUCTION PER 1,000 GALLONS OF WATER FURNISHED.

Water furnished (gallons).	Private plants.			Municipal plants.		
		Average cost of production per 1,000 gallons.			Average cost of production per 1,000 gallons.	
	Number reporting.	Excluding depreciation, taxes, and interest on total investment.	Including depreciation, taxes, and estimated interest on total investment.	Number reporting.	Excluding depreciation and interest on total investment	Including depreciation, estimated taxes, interest on total investment, etc.
Under 1,000.000	.....	....	....	5	$1.0574	$2.3908
1,000,000 and under 5,000,000	5	$0.1464	$0.6928	35	.2988	.8789
5,000,000 and under 10,000,000	12	.1535	.4966	35	.1503	.4426
10,000,000 and under 15,000,000	12	.1382	.4092	45	.1158	.3050
15,000,000 and under 20,000,000	10	.0962	.3066	41	.1018	.2636
20,000,000 and under 25,000,000	12	.1020	.2471	26	.0848	.2911
25,000,000 and under 50,000,000	50	.0585	.1874	105	.0606	.1754
50,000,000 and under 75,000,000	44	.0434	.1375	52	.0423	.1180
75,000,000 and under 100,000,000	26	.0511	.1520	24	.0461	.1371
100,000,000 and under 125,000,000	20	.0368	.1084	23	.0342	.1015
125,000,000 and under 150,000,000	9	.0377	.1285	22	.0381	.1265
150,000,000 and under 175,000,000	14	.0408	.1108	6	.0164	.0879
175,000,000 and under 200,000,000	8	.0470	.1339	12	.0254	.0845
200,000,000 and under 250,000,000	23	.0363	.1165	15	.0269	.1046
250,000,000 and under 500,000 000	51	.0251	.0796	58	.0227	.0858
500,000,000 and under 750,000,000	30	.0206	.0762	38	.0252	.0902
750,000,000 and under 1,000,000,000	14	.0194	.0672	20	.0195	.0745
1,000,000,000 and under 5,000,000,000	30	.0176	.0651	78	.0175	.0639
5,000,000,000 and under 10,000,000,000	4	.0291	.1163	6	.0107	.0444
10,000,000,000 or over	.....	....	....	13	.0167	.0476

Taking up first the comparison of these groups exclusive of depreciation, taxes, and interest on the total investment and dropping from consideration the first two groups for the reasons stated in the text in connection with the short table preceding relating to cost of salaries and wages, it is seen that in the group of plants furnishing 5,000,000 and under 10,000,000 gallons of water during the year, as well as in the group following, the average cost was greater in the private plants than in the municipal, while in the next group the opposite is true. In the sixth group the cost was greater in the private plants, while in the following group the result was again reversed. In the next eight groups, with one exception, the cost was greater in the private plants, in the group following it was greater in the municipal plants, while in the next two groups it was practically the same in both classes of plants. In the last group having private plants the average cost of production exclusive of the elements mentioned above was $0.0291 per 1,000 gallons in the four private plants and $0.0107 in the six municipal plants, or more than two and one-half times as great in the private as in the municipal plants.

Taking up the two columns showing the average cost of production per 1,000 gallons during the year in private and municipal plants includ-

ing depreciation, taxes, and interest on the total investment, it is seen that, beginning with the group of plants furnishing 5,000,000 and under 10,000,000 gallons of water during the year, the first twelve groups, with one exception, show a greater cost in the private plants than in those under municipal ownership and control, while the next three groups show a cost in the municipal plants in excess of that in the private plants. In the last two groups in which comparison can be made the cost in the private plants exceeds that in the municipal, this excess in the case of the last group being quite large.

A short table showing the range of costs in the last five groups of the preceding table has also been prepared. This table follows and shows the lowest and highest, as well as the average cost, in each class of plants (private and municipal) in each of the five groups which contain plants having the largest production.

LOWEST, HIGHEST, AND AVERAGE COST OF PRODUCTION PER 1,000 GALLONS OF WATER FURNISHED IN FIVE GROUPS OF PLANTS.

Water furnished (gallons).	Private plants.		
	Number.	Lowest, highest, and average cost of production per 1,000 gallons.	
		Excluding depreciation, taxes, and interest on total investment.	Including depreciation, taxes, and estimated interest on total investment.
500,000,000 and under 750,000,000	30	\$0.0052-\$0.0398-\$0.0206	\$0.0288-\$0.1890- \$0.0762
750,000,000 and under 1,000,000,000	14	.0096- .0264- .0194	.0187- .1235- .0672
1,000,000,000 and under 5,000,000,000	30	.0029- .0379- .0176	.0162- .1509- .0651
5,000,000,000 and under 10,000,000,000	4	.0049- .0448- .0291	.0247- .1886- .1163
10,000,000,000 or over	....	....	....

Water furnished (gallons).	Municipal plants.		
	Number.	Lowest, highest, and average cost of production per 1,000 gallons.	
		Excluding depreciation and interest on total investment.	Including depreciation, estimated taxes, interest on total investment, etc.
500,000,000 and under 750,000,000	38	\$0.0057-\$0.0675-\$0.0252	\$0.0169-\$0.3354- \$0.0902
750,000,000 and under 1,000,000,000	20	.0078- .0511- .0195	.0265- .2142- .0745
1,000,000,000 and under 5,000,000,000	78	.0028- .0370- .0175	.0171- .2627- .0639
5,000,000,000 and under 10,000,000,000	6	.0044- .0163- .0107	.0130- .0729- .0444
10,000,000,000 or over	13	.0084- .0363- .0167	.0262- .1265- .0476

As regards actual prices—those based on the total quantity of water sold and the total income from the same—it may be interesting to examine the short table which follows. This table shows the average price received per 1,000 gallons for all water sold by private and municipal plants, classified according to the groups adopted in the general tables. The cost of production is not considered here, and for this reason the

water furnished by municipal plants for public use is not included. The results have been found by using simply the absolute figures as to the quantity of water sold by each of the two classes of plants, and the income derived from such sale.

AVERAGE PRICE PER 1,000 GALLONS OF WATER SOLD.

Water furnished (gallons).	Private plants.		Municipal plants.	
	Number.	Average price per 1,000 gallons of water sold.	Number.	Average price per 1,000 gallons of water sold.
Under 1,000,000	....	....	5	$0.5608
1,000,000 and under 5,000,000	5	$0.4476	35	.2031
5,000,000 and under 10,000,000	12	.3476	35	.1579
10,000,000 and under 15,000,000	22	.2521	45	.1445
15,000,000 and under 20,000,000	10	.2372	41	.1090
20,000,000 and under 25,000,000	12	.2164	26	.1108
25,000,000 and under 50,000,000	50	.1524	105	.0840
50,000,000 and under 75,000,000	44	.1281	52	.0743
75,000,000 and under 100,000,000	26	.1183	24	.0792
100,000,000 and under 125,000,000	20	.0973	23	.0639
125,000,000 and under 150,000,000	9	.1059	22	.0640
150,000,000 and under 175,000,000	14	.0902	6	.0580
175,000,000 and under 200,000,000	8	.0981	12	.0693
200,000,000 and under 250,000,000	23	.0963	15	.0889
250,000,000 and under 500,000,000	52	.0705	58	.0615
500,000,000 and under 750,000,000	30	.0589	38	.0708
750,000,000 and under 1,000,000,000	14	.0618	20	.0610
1,000,000,000 and under 5,000,000,000	30	.0563	78	.0593
5,000,000,000 and under 10,000,000,000	4	.1136	6	.0471
10,000,000,000 or over	....	....	13	.0526

An examination of the table shows that in every group of plants except two the average price charged per 1,000 gallons is smaller in municipal than in private plants. This table when studied in connection with a preceding short table (above), showing the cost of production per 1,000 gallons of water furnished for consumption, affords some interesting comparisons. In that table and this one the same figures are used in private plants as to the quantity of water considered. The figures as to price and cost of production should, therefore, be properly comparable. The figures in that table are first given as showing the cost of production excluding depreciation, taxes, and interest on the investment or cost of works, and next given including these elements. Taking the column showing the latter statement it is seen that interest is included and that the column therefore shows the figures at which the water could be sold and yield a dividend or profit on the amount of the total investment equal to the rate of interest paid on the last issue of city bonds. It would naturally be supposed that the average prices secured by private plants would at least be as large as these figures, but a comparison shows that in none of the groups does the average price charged for the water sold equal the cost of production after providing for depreciation, taxes, and a reasonable profit on the investment

—a profit equivalent to the interest paid by the city on its last issue of municipal bonds. So far as municipal plants are concerned the short table immediately preceding necessarily shows prices only for water sold, the quantity furnished for the public service being excluded. A comparison of these prices with the figures in the former short table referred to, giving the average cost of production per 1,000 gallons of water furnished, including depreciation, estimated taxes, interest on total investment, etc., shows that this cost exceeds the price charged in all of the groups except the last two. In these two groups, made up of the nineteen largest municipal plants for which reports were secured, the average price charged private consumers was in excess of the cost of production, including all of the additional elements theoretically entering into the same. The explanation of these results as regards the relation between cost of production and prices may be found in the fact that depreciation, which is here included in the cost of production, is, as a rule, not considered by the plants themselves as an actual charge against cost, and that prices are consequently based on cost exclusive of this element. The reasons for furnishing a statement which includes this element, however, and the manner in which the figures were obtained, have been fully set forth in the discussion of Table VI, preceding.

GAS WORKS

Salaries and Wages

In connection with the cost of salaries and wages in municipal and private plants a short table has been prepared, similar to that shown under waterworks, giving the average cost of salaries and of wages per 1,000,000 cubic feet of gas produced. This table, which follows, includes all plants for which separate figures for the quantity of gas produced and for salaries and wages during their last fiscal year were secured.

AVERAGE COST OF SALARIES AND WAGES PER 1,000,000 CUBIC FEET OF GAS PRODUCED.

Gas produced (cubic feet).	Private plants.			Municipal plants.		
	Number reporting.	Average cost per 1,000,000 cubic feet.		Number reporting.	Average cost per 1,000,000, cubic feet.	
		Salaries.	Wages.		Salaries.	Wages.
Under 2,000,000	7	$353.36	$540.56	1	$457.32	$603.93
2,000,000 and under 5,000,000	62	215.87	280.24	2	230.77	131.09
5,000,000 and under 10,000,000	59	181.16	221.33	2	130.17	234.23
10,000,000 and under 15,000,000	42	155.42	212.63	....	....	....
15,000,000 and under 20,000,000	43	141.06	198.21	2	57.00	183.06
20,000,000 and under 25,000,000	23	140.89	183.51	1	73.44	227.39
25,000,000 and under 50,000,000	38	115.21	183.59	1	70.57	167.13
50,000,000 and under 75,000,000	16	96.14	154.35	....	....	....
75,000,000 and under 100,000,000	9	86.25	141.75	....	....	....
100,000,000 and under 500,000,000	17	64.03	150.52	2	28.41	229.57
500,000,000 or over	8	31.57	122.24	....	....	....

It is to be regretted that the small number of municipal gas plants in operation in the country (14), and the consequent small number for which schedules were secured (11), detracts somewhat from a comparison between private and municipal plants as to salary and wage cost. For the plants reporting, however, it is seen that, so far as salaries are concerned, the average cost in the first two groups is somewhat larger in municipal plants than in those under private ownership and control. In all the other groups, however, which contain both private and municipal plants, the cost in private plants exceeds that in municipal plants, and in some cases this excess is considerable. So far as wage cost is concerned, four of the groups show a larger cost in municipal plants than in private, while the opposite is true in three cases, in one of which the average cost in the private plants is more than double that in the plants under municipal ownership.

It has been found possible to summarize the results as to the cost of production, and, accordingly, several tables have been made, one showing the cost of production per 1,000 cubic feet of gas produced and two others showing this cost per 1,000 cubic feet of gas sold. In presenting these tables it is proper to say that, before making the various calculations found therein, the value of the residuals and by-products which were sold by the various plants has been deducted from the cost of production. The first table, then, shows for the private and municipal plants falling under each of the groups used in the general tables the average cost of production per 1,000 cubic feet of gas produced during the fiscal year for which report was made by the various plants. In order that private and municipal plants may be placed on the same basis for comparison in this table, two columns showing cost have been made for each of the two classes of plants. The first of these columns shows the average cost of production excluding depreciation, taxes, and interest on the total investment (cost of plant). Depreciation is to some extent a theoretical element, and for this reason some may wish to see the figures with this element excluded. Taxes have not been included in the case of private plants, because taxes are not a cost in municipal plants; while interest on the total investment is excluded, because of the fact that private or corporate owners do not usually borrow money for the investment and pay interest on the same, as is done by cities, but issue and sell stock for this purpose. Bonds, it is true, are also sometimes issued by private plants, and in such cases there is a regular interest charge; but the practice is far from uniform. With these elements eliminated in both classes of plants, only the actual cost for

administration, labor, materials and supplies, general distributing expenses, and repairs and renewals are taken into consideration. The second column, showing cost for each of the two classes of plants, on the other hand, includes depreciation, taxes, and interest on the total investment (cost of plant). Interest has in all cases been estimated at the rate paid by the city on its last issue of bonds. Private and municipal plants are thus put upon the same basis. The assumption of this rate as applied to private plants is justified by the probability that the municipality could raise funds for the establishment of such a plant at the rate paid upon its last issue of bonds, and that therefore for a fair comparison the same rate should be used for both classes of plants. Some private plants, it is true, will be found paying interest charges in excess of this estimate, because of the fact that bonds have been issued at a higher rate of interest or in excess of the cost of the plant. It is well understood that municipal plants do not pay taxes, but in order to furnish a fair basis for comparison estimates have been inserted representing the taxes that would have been collected from these plants had they been owned by private individuals or corporations. It will be seen at once that plants owned and operated by municipalities take the place of just so much private property from which taxes would be received to the amount estimated, the ownership on the part of cities involving a definite decrease in the amount of taxable property. The estimates are based on the judgment of the local assessors as to the assessed value of the plants considered. The table follows:

AVERAGE COST OF PRODUCTION PER 1,000 CUBIC FEET OF GAS PRODUCED.

[The value of the residuals and by-products which were sold by the various plants has been deducted from the cost of production before using the same as the basis for this table.]

Gas produced (cubic feet).	Private plants.			Municipal plants.		
	Number reporting.	Average cost of production per 1,000 cubic feet. Excluding depreciation, taxes, and interest on total investment	Average cost of production per 1,000 cubic feet. Including depreciation, taxes, and estimated interest on total investment.	Number reporting.	Average cost of production per 1,000 cubic feet. Excluding depreciation and interest on total investment.	Average cost of production per 1,000 cubic feet. Including depreciation, estimated taxes, interest on total investment, etc.
Under 2,000,000	10	$1.86	$3.71	1	$2.26	$3 34
2,000,000 and under 5,000,000	69	1.18	2.17	2	.69	1 18
5,000,000 and under 10,000,000	63	.98	1.84	2	.82	1.51
10,000,000 and under 15,000,000	43	.79	1.44	......	....	....
15,000,000 and under 20,000,000	45	.78	1.52	2	.60	.96
20,000,000 and under 25,000,000	23	.78	1.35	1	.68	1.03
25,000,000 and under 50,000,000	38	.68	1.25	1	.55	.91
50,000,000 and under 75,000,000	17	.65	1.14	......	....	....
75,000,000 and under 100,000,000	9	.61	1.06	......	....	....
100,000,000 and under 500,000,000	18	.45	.92	2	.44	.63
500,000,000 or over	8	.46	.76	......	....	....

Taking up the comparison of the plants in each of the groups in which comparison is possible, it is seen that the columns giving the average cost of production excluding depreciation, taxes, and interest on total investment show that in all groups except the first the average cost per 1,000 cubic feet of gas produced is less in municipal plants than in private; while the columns giving the average cost including these elements show in every group of plants an excess of cost in private plants. As will be seen by reference to Table V, quite a considerable income was derived in some plants from the sale of by-products and residuals, and, as has been stated, the amounts derived from this source have been deducted from the cost of production in every case before using the figures as a basis for this table.

In Table VII it is shown that in all plants engaged in making gas quite a considerable per cent of the product is lost by leakage before being sold; also a considerable quantity is used at the works and offices of the plants. Owing to this portion of the product that is either lost by leakage or used by the plants, and the fact that no revenue is derived from the same, it has been thought best to make another table based on the quantity of gas actually furnished for consumption to private users and to the municipality. The second of the tables referred to has been constructed on this basis and the result follows.

AVERAGE COST OF PRODUCTION PER 1,000 CUBIC FEET OF GAS FURNISHED FOR CONSUMPTION.

[The value of the residuals and by-products which were sold by the various plants has been deducted from the cost of production before using the same as the basis for this table.]

Gas produced (cubic feet).	Private plants.			Municipal plants.		
	Number reporting.	Average cost of production per 1,000 cubic feet.		Number reporting.	Average cost of production per 1,000 cubic feet.	
		Excluding depreciation, taxes, and interest on total investment	Including depreciation, taxes, and estimated interest on total investment.		Excluding depreciation and interest on total investment.	Including depreciation, estimated taxes, interest on total investment, etc.
Under 2,000,000	11	$2.28	$4.46	1	$2.80	$4.15
2,000,000 and under 5,000,000	69	1.38	2.55	2	.85	1.45
5,000,000 and under 10,000,000	63	1.17	2.20	2	.96	1.78
10,000,000 and under 15,000,000	42	.96	1.73	......	....	....
15,000,000 and under 20,000,000	44	.92	1.80	2	.69	1.12
20,000,000 and under 25,000,000	22	.90	1.55	1	.79	1.20
25,000,000 and under 50,000,000	38	.81	1.49	1	.62	1.03
50,000,000 and under 75,000,000	17	.75	1.33	......	....	....
75,000,000 and under 100,000,000	9	.72	1.25	......	....	....
100,000,000 and under 500,000,000	17	.49	1.02	2	.51	.73
500,000,000 or over	8	.51	.84	......	....	....

This table is quite similar to the one immediately preceding, and shows that in all of the groups except two the average cost of produc-

—a profit equivalent to the interest paid by the city on its last issue of municipal bonds. So far as municipal plants are concerned the short table immediately preceding necessarily shows prices only for water sold, the quantity furnished for the public service being excluded. A comparison of these prices with the figures in the former short table referred to, giving the average cost of production per 1,000 gallons of water furnished, including depreciation, estimated taxes, interest on total investment, etc., shows that this cost exceeds the price charged in all of the groups except the last two. In these two groups, made up of the nineteen largest municipal plants for which reports were secured, the average price charged private consumers was in excess of the cost of production, including all of the additional elements theoretically entering into the same. The explanation of these results as regards the relation between cost of production and prices may be found in the fact that depreciation, which is here included in the cost of production, is, as a rule, not considered by the plants themselves as an actual charge against cost, and that prices are consequently based on cost exclusive of this element. The reasons for furnishing a statement which includes this element, however, and the manner in which the figures were obtained, have been fully set forth in the discussion of Table VI, preceding.

GAS WORKS

Salaries and Wages

In connection with the cost of salaries and wages in municipal and private plants a short table has been prepared, similar to that shown under waterworks, giving the average cost of salaries and of wages per 1,000,000 cubic feet of gas produced. This table, which follows, includes all plants for which separate figures for the quantity of gas produced and for salaries and wages during their last fiscal year were secured.

AVERAGE COST OF SALARIES AND WAGES PER 1,000,000 CUBIC FEET OF GAS PRODUCED.

Gas produced (cubic feet).	Private plants.			Municipal plants.		
	Number reporting.	Average cost per 1,000,000 cubic feet.		Number reporting.	Average cost per 1,000,000, cubic feet.	
		Salaries.	Wages.		Salaries.	Wages.
Under 2,000,000	7	$353.36	$540.56	1	$457.32	$603.93
2,000,000 and under 5,000,000	62	215.87	280.24	2	230.77	131.09
5,000,000 and under 10,000,000	59	181.16	221.33	2	130.17	234.23
10,000,000 and under 15,000,000	42	155.42	212 63	......	......	......
15,000,000 and under 20,000,000	43	141.06	198.21	2	57.00	183 06
20,000,000 and under 25,000,000	23	140.89	183.51	1	73 44	227.39
25,000,000 and under 50,000,000	38	115.21	183.59	1	70.57	167.13
50,000,000 and under 75,000,000	16	96.14	154 35	......	......	......
75,000,000 and under 100,000,000	9	86.25	141 75	......	......	......
100,000,000 and under 500,000,000	17	64.03	150.52	2	28.41	229.57
500,000,000 or over	8	31.57	122.24	......	......	......

It is to be regretted that the small number of municipal gas plants in operation in the country (14), and the consequent small number for which schedules were secured (11), detracts somewhat from a comparison between private and municipal plants as to salary and wage cost. For the plants reporting, however, it is seen that, so far as salaries are concerned, the average cost in the first two groups is somewhat larger in municipal plants than in those under private ownership and control. In all the other groups, however, which contain both private and municipal plants, the cost in private plants exceeds that in municipal plants, and in some cases this excess is considerable. So far as wage cost is concerned, four of the groups show a larger cost in municipal plants than in private, while the opposite is true in three cases, in one of which the average cost in the private plants is more than double that in the plants under municipal ownership.

It has been found possible to summarize the results as to the cost of production, and, accordingly, several tables have been made, one showing the cost of production per 1,000 cubic feet of gas produced and two others showing this cost per 1,000 cubic feet of gas sold. In presenting these tables it is proper to say that, before making the various calculations found therein, the value of the residuals and by-products which were sold by the various plants has been deducted from the cost of production. The first table, then, shows for the private and municipal plants falling under each of the groups used in the general tables the average cost of production per 1,000 cubic feet of gas produced during the fiscal year for which report was made by the various plants. In order that private and municipal plants may be placed on the same basis for comparison in this table, two columns showing cost have been made for each of the two classes of plants. The first of these columns shows the average cost of production excluding depreciation, taxes, and interest on the total investment (cost of plant). Depreciation is to some extent a theoretical element, and for this reason some may wish to see the figures with this element excluded. Taxes have not been included in the case of private plants, because taxes are not a cost in municipal plants; while interest on the total investment is excluded, because of the fact that private or corporate owners do not usually borrow money for the investment and pay interest on the same, as is done by cities, but issue and sell stock for this purpose. Bonds, it is true, are also sometimes issued by private plants, and in such cases there is a regular interest charge; but the practice is far from uniform. With these elements eliminated in both classes of plants, only the actual cost for

administration, labor, materials and supplies, general distributing expenses, and repairs and renewals are taken into consideration. The second column, showing cost for each of the two classes of plants, on the other hand, includes depreciation, taxes, and interest on the total investment (cost of plant). Interest has in all cases been estimated at the rate paid by the city on its last issue of bonds. Private and municipal plants are thus put upon the same basis. The assumption of this rate as applied to private plants is justified by the probability that the municipality could raise funds for the establishment of such a plant at the rate paid upon its last issue of bonds, and that therefore for a fair comparison the same rate should be used for both classes of plants. Some private plants, it is true, will be found paying interest charges in excess of this estimate, because of the fact that bonds have been issued at a higher rate of interest or in excess of the cost of the plant. It is well understood that municipal plants do not pay taxes, but in order to furnish a fair basis for comparison estimates have been inserted representing the taxes that would have been collected from these plants had they been owned by private individuals or corporations. It will be seen at once that plants owned and operated by municipalities take the place of just so much private property from which taxes would be received to the amount estimated, the ownership on the part of cities involving a definite decrease in the amount of taxable property. The estimates are based on the judgment of the local assessors as to the assessed value of the plants considered. The table follows:

AVERAGE COST OF PRODUCTION PER 1,000 CUBIC FEET OF GAS PRODUCED.

[The value of the residuals and by-products which were sold by the various plants has been deducted from the cost of production before using the same as the basis for this table.]

Gas produced (cubic feet).	Private plants.			Municipal plants.		
	Number reporting.	Average cost of production per 1,000 cubic feet.		Number reporting.	Average cost of production per 1,000 cubic feet.	
		Excluding depreciation, taxes, and interest on total investment	Including depreciation, taxes, and estimated interest on total investment.		Excluding depreciation and interest on total investment.	Including depreciation, estimated taxes, interest on total investment, etc.
Under 2,000,000	10	$1.86	$3.71	1	$2.26	$3.34
2,000,000 and under 5,000,000	69	1.18	2.17	2	.69	1.18
5,000,000 and under 10,000,000	63	.98	1.84	2	.82	1.51
10,000,000 and under 15,000,000	43	.79	1.44	......	....	....
15,000,000 and under 20,000,000	45	.78	1.52	2	.60	.96
20,000,000 and under 25,000,000	23	.78	1.35	1	.68	1.03
25,000,000 and under 50,000,000	38	.68	1.25	1	.55	.91
50,000,000 and under 75,000,000	17	.65	1.14	......	....	....
75,000,000 and under 100,000,000	9	.61	1.06	......	....	....
100,000,000 and under 500,000,000	18	.45	.92	2	.44	.63
500,000,000 or over	8	.46	.76	......	....	....

Taking up the comparison of the plants in each of the groups in which comparison is possible, it is seen that the columns giving the average cost of production excluding depreciation, taxes, and interest on total investment show that in all groups except the first the average cost per 1,000 cubic feet of gas produced is less in municipal plants than in private; while the columns giving the average cost including these elements show in every group of plants an excess of cost in private plants. As will be seen by reference to Table V, quite a considerable income was derived in some plants from the sale of by-products and residuals, and, as has been stated, the amounts derived from this source have been deducted from the cost of production in every case before using the figures as a basis for this table.

In Table VII it is shown that in all plants engaged in making gas quite a considerable per cent of the product is lost by leakage before being sold; also a considerable quantity is used at the works and offices of the plants. Owing to this portion of the product that is either lost by leakage or used by the plants, and the fact that no revenue is derived from the same, it has been thought best to make another table based on the quantity of gas actually furnished for consumption to private users and to the municipality. The second of the tables referred to has been constructed on this basis and the result follows.

AVERAGE COST OF PRODUCTION PER 1,000 CUBIC FEET OF GAS FURNISHED FOR CONSUMPTION.

[The value of the residuals and by-products which were sold by the various plants has been deducted from the cost of production before using the same as the basis for this table.]

Gas produced (cubic feet).	Private plants.			Municipal plants.		
	Number reporting.	Average cost of production per 1,000 cubic feet.		Number reporting.	Average cost of production per 1,000 cubic feet.	
		Excluding depreciation, taxes, and interest on total investment	Including depreciation, taxes, and estimated interest on total investment.		Excluding depreciation and interest on total investment.	Including depreciation, estimated taxes, interest on total investment, etc.
Under 2,000,000	11	$2.28	$4.46	1	$2.80	$4.15
2,000,000 and under 5,000,000	69	1.38	2.55	2	.85	1.45
5,000,000 and under 10,000,000	63	1.17	2.20	2	.96	1.78
10,000,000 and under 15,000,000	42	.96	1.73	......	......	......
15,000,000 and under 20,000,000	44	.92	1.80	2	.69	1.12
20,000,000 and under 25,000,000	22	.90	1.55	1	.79	1.20
25,000,000 and under 50,000,000	38	.81	1.49	1	.62	1.03
50,000,000 and under 75,000,000	17	.75	1.33	......	......	......
75,000,000 and under 100,000,000	9	.72	1.25	......	......	......
100,000,000 and under 500,000,000	17	.49	1.02	2	.51	.73
500,000,000 or over	8	.51	.84	......	......	......

This table is quite similar to the one immediately preceding, and shows that in all of the groups except two the average cost of produc-

tion per 1,000 cubic feet of gas furnished for consumption excluding the elements of depreciation, taxes, and interest on the total investment is greater in private than in municipal plants. If these elements are included, it is shown that the cost is less in the municipal plants in every group affording a comparison.

A short table showing the range of costs in the last five groups of the preceding table has also been prepared. This table follows, and shows the lowest and highest, as well as the average, cost in each class of plants (private and municipal) in each of the five groups which contain plants having the largest production.

LOWEST, HIGHEST, AND AVERAGE COST OF PRODUCTION PER 1,000 CUBIC FEET OF GAS FURNISHED FOR CONSUMPTION IN FIVE GROUPS OF PLANTS.

Gas produced (cubic feet).	Private plants.		
	Number reporting	Lowest, highest, and average cost of production per 1,000 cubic feet.	
		Excluding depreciation, taxes, and interest on total investment.	Including depreciation, taxes, and estimated interest on total investment.
25,000,000 and under 50,000,000	38	$0.36-$1.99-$0.81	$0.68-$3.41-$1.49
50,000,000 and under 75,000,000	17	.57- 1.04- .75	.86- 2.35- 1.33
75,000,000 and under 100,000,000	9	.47- 1.00- .72	1.06- 1.65- 1.25
100,000,000 and under 500,000,000	17	.16- .95- .49	.58- 1.73- 1.02
500,000,000 or over	8	.40- .84- .51	.75- 1.44- .84

Gas produced (cubic feet).	Municipal plants.		
	Number reporting	Lowest, highest, and average cost of production per 1,000 cubic feet.	
		Excluding depreciation and interest on total investment.	Including depreciation, estimated taxes, interest on total investment, etc.
25,000,000 and under 50,000,000	1	$0.62-$0.62-$0.62	$1.03-$1.03-$1.03
50,000,000 and under 75,000,000	....	....	....
75,000,000 and under 100,000,000	....	....	....
100,000,000 and under 500,000,000	2	.46- .54- .51	.62- .79- .73
500,000,000 or over	....	....	....

During the course of the investigation complete statements as regards cost of production were secured from twelve plants, which are not included in the general tables owing to the fact that the officers were unwilling to furnish all the data called for by the schedule of inquiries used by the Department. These twelve plants are located in twelve cities, and are owned and operated by as many distinct private corporations, but are all under a single control or supervision. The properties in each case have been acquired by purchase during the last twelve years. All of these plants appear to have been operated under exceptionally good management, and it is therefore interesting to know the

results of the same. The various plants use all systems making coal, oil, and water gas. The facts relating to the twelve plants, combined as furnished to the Department, are presented in the statement which follows. The cost of these plants was approximately $10,000,000, this sum being divided among the various items as follows: Land, $1,000,000; buildings, $1,000,000; equipment within works, $2,000,000; holders, $1,000,000; mains, $3,800,000; meters, $1,000,000, and teams, tools, and other accessories, $200,000.

The general statement as to cost of production during the fiscal year considered is as follows:

General expenses:			
Salaries of officers, superintendents, clerks, etc.		$124,419	
Office supplies and expenses		32,209	
Insurance		5,070	
Legal expenses and damages		3,310	
Other		7,491	
Total			$172,499
Wages			251,626
Materials and supplies:			
Fuel		$ 10,385	
Materials used in manufacture		397,744	
Other supplies		38,324	
Total			446,453
General distributing expenses			88,578
Maintenance:			
Actual disbursements for repairs and renewals—			
On works	$73,755		
On mains	12,630		
Other	30,739		
Total for repairs and renewals		$117,124	
Estimated depreciation—			
On buildings	$20,000		
On manufacturing equipment	60,000		
On distributing system, meters, and apparatus	70,000		
Total depreciation		150,000	
Total maintenance			267,124
Total cost of production { including depreciation			$1,226,280
Total cost of production { excluding depreciation			1,076,280
Taxes			81 565
Total cost of production and taxes { including depreciation			1,307,845
Total cost of production and taxes { excluding depreciation			1,157,845

There were made during the year 3,176,646,900 cubic feet of gas, of which 152,784,513 feet, or slightly under 5 per cent, were lost by leakage, 3,996,900 feet were used at the works and offices, and 3,018,243,987 feet were sold. There were on hand at the beginning of the year 2,832,700 feet of gas, and at the end of the year, 4,454,200 feet. The total income for the year was $3,405,781, and the cost of production

including taxes, depreciation, and interest on the investment at the average rate paid on the last issues of bonds in the cities involved (3.5 per cent) was $1,657,845, leaving a net profit of $1,747,936 over and above the cost shown in the preceding statement. From these statements it is seen that the average cost of production in the twelve plants excluding depreciation, taxes, and interest on the investment at 3.5 per cent was 23 cents per 1,000 cubic feet of gas sold, and, including the above-mentioned elements, 42 cents per 1,000 cubic feet of gas sold. The amount received from the sale of residuals and by-products has, of course, been deducted from the cost of production in the calculation of the average cost per 1,000 cubic feet of gas sold, as shown above.

If any comparison of cost of production be made between these twelve plants and any plants included in the general tables, or between any of the individual plants of those tables, it should be done with the most careful regard to the varying conditions of equipment, kind of gas manufactured, cost of fuel and other materials and supplies, quantity of gas manufactured and sold, the conditions of distribution, etc. Comparisons of cost between plant and plant cannot fairly be made without a study of all these facts which for the individual plants are shown in the general tables. It will thus be seen that no plant can be selected as representative of all or any large class, and that no amount of cost, either for the items or for the total, can be established as a criterion for other plants, speaking generally and without such study as has been indicated above.

PRICES

The prices shown in this table are somewhat unsatisfactory when we attempt to use them for comparative purposes, owing to the fact that quite generally the real price is considerably under the price charged owing to the discounts which are allowed for the various reasons stated. As these discounts are not uniform in the various plants, quite a considerable amount of calculation is necessary in comparing two or more plants as regards prices. So far, however, as the actual prices are concerned—that is, those based on the total quantity of gas sold and the total income from the same—it may be interesting to examine the short table which follows. This table shows the average price received per 1,000 cubic feet for all gas sold by private and municipal plants classified according to the groups adopted in the general tables. The cost of production is not considered here, and for this reason the gas furnished

by municipal plants for public use is not included. The results have been found by using simply the absolute figures as to the quantity of gas sold by each of the two classes of plants and the income derived from such sale. The table follows:

AVERAGE PRICE PER 1,000 CUBIC FEET OF GAS SOLD.

Gas produced (cubic feet).	Private plants.		Municipal plants.	
	Number reporting.	Average price per 1,000 cubic feet.	Number reporting.	Average price per 1,000 cubic feet.
Under 2,000,000	11	$2.65	1	$2.64
2,000,000 and under 5,000,000	69	1.85	2	2.42
5,000,000 and under 10,000,000	63	1.64	2	1.62
10,000,000 and under 15,000,000	42	1.54	....	....
15,000,000 and under 20,000,000	44	1.58	2	.86
20,000,000 and under 25,000,000	22	1.50	1	1.34
25,000,000 and under 50,000,000	38	1.40	1	.80
50,000,000 and under 75,000,000	17	1.44	....	....
75,000,000 and under 100,000,000	9	1.27	....	....
100,000,000 and under 500,000,000	17	1.16	2	.92
500,000,000 or over	8	1.12	....	....

An examination of the above table shows that in every group of plants except one the average price charged per 1,000 cubic feet is smaller in municipal than in private plants. This table when studied in connection with a preceding short table (above), showing the cost of production per 1,000 cubic feet of, gas furnished for consumption affords some interesting comparisons. In that table and in this one the same figures are used in the private plants as to quantity of gas considered, and the figures as to price and cost of production should, therefore, be properly comparable. The figures in that table are first given as showing cost of production excluding depreciation, taxes, and interest on the investment or cost of works, and next given including these elements. Taking the column showing the latter statement, it is seen that interest is included, and that the column therefore shows the figures at which the gas could be sold and yield a dividend or profit on the amount of the total investment equal to the rate of interest paid on the last issue of city bonds. It would naturally be supposed that the average prices secured by private plants would at least be as large as these figures, but a comparison shows that in only the four largest groups does the average price charged for the gas sold exceed the cost of production after providing for depreciation, taxes, and a reasonable profit on the investment —a profit equal to the interest paid by the city on its last issue of municipal bonds. So far as municipal plants are concerned, the short table necessarily shows prices only for gas sold, the quantity furnished for the public service being excluded. A comparison of these prices with

the figures in the former short table referred to, giving the average cost of production per 1,000 cubic feet of gas furnished including depreciation, estimated taxes, interest on total investment, etc., shows that this cost exceeds the price charged in four of the groups, while in three of the groups the average price charged private consumers was in excess of the cost of production, including all the elements theoretically entering into the same. The explanation of these results as regards the relation between cost of production and prices may be found in the fact that depreciation, which is here included in the cost of production, is, as a rule, not considered by the plants themselves as an actual charge against cost, and that prices are consequently based on cost exculsive of this element. The reasons for furnishing a statement which includes this element, however, and the manner in which the figures were obtained, have been fully set forth in the discussion of Table VI.

ELECTRIC LIGHT PLANTS

Salaries and Wages

As is seen by reference to Table VI, separate figures for salaries and wages have not been secured for all of the 952 plants covered, a portion or all of the wage cost being included in salaries in some plants and *vice versa*. For 576 private plants and 245 municipal plants, however, the accounts were kept separately and accurate data were obtained. The short table which follows is based on the plants reporting separately as to the cost of salaries and wages during their last fiscal year, and shows for each of the groups adopted in the general tables the average cost of salaries and wages per plant. While it would have been preferable to make some unit of the product the basis for this average cost of salaries and wages, this could not be done owing to the impossibility, as previously stated, of reducing the product to a uniform unit. It is believed, however, that a comparison of these groups based on the horse-power capacity of engines will show approximately the conditions as to the cost in the two classes of plants. The table follows.

AVERAGE COST OF SALARIES AND WAGES PER PLANT.

Plants having engines with horse-power of—	Private plants.			Municipal plants.		
	Number reporting	Average cost per plant		Number reporting	Average cost per plant	
		Salaries.	Wages.		Salaries.	Wages.
Under 50	6	$ 261.66	$ 450.00	5	$ 102.60	$ 682.00
50 and under 75	33	581.00	784.70	15	258.00	984.13
75 and under 100	29	558.86	835.41	27	358.78	824.22
100 and under 125	41	697.07	1,002.90	41	423.17	846.85
125 and under 150	32	740.59	1,053.28	27	579.11	1,006.41
150 and under 200	58	857.93	1,499.55	31	587.23	1,288.74
200 and under 300	86	1,092.81	1,959.42	48	826.63	2,116 79
300 and under 400	44	1,711.95	3,232.09	21	1,005.33	2,822.24
400 and under 500	39	2,269.26	3,843.59	9	1,063.00	4,760.33
500 and under 750	65	2,592.35	5,150.29	9	1,135.78	4,292.22
750 and under 1,000	44	3,738.20	8,494.27	3	1,726.33	6,766.33
1,000 and under 1,500	34	4,744.12	10,026.00	4	3,785.00	11,425.50
1,500 and under 2,000	20	5,611.00	14,082.10	2	3,675.00	17,421.50
2,000 and under 3,000	20	9,889.30	23,064.65	2	6,366.00	47,566.00
3,000 and under 5,000	11	15,150.64	26,422.27	1	3,493.00	12,318.00
5,000 or over	14	35,462.86	69,146.50	....	....	....

In the above table it is seen that so far as salaries are concerned the average cost in municipal plants is smaller in every group presented, in some cases being less than half the average cost in private plants. As regards wage cost, it is seen that in seven of the groups shown the average cost in the municipal plants exceeds that in the private plants, while in eight of the groups this cost in the private plants is greater than in those municipally owned and controlled.

Prices

Owing to the difficulties already mentioned as to comparisons between individual plants regarding prices, several summary tables have been made, bringing together by groups all of the facts which could properly be brought into comparison. The groups adopted are those used in the general tables. Of the two summaries relating to arc lighting, one of the short tables, showing the average price per lamp per year of arc lighting by hours of service rendered, is inserted in the analysis of Table XI, being based on that table, while the other table, showing the average price per kilowatt hour charged in the arc service, and based on the table under discussion, follows:

AVERAGE PRICE PER KILOWATT HOUR CHARGED IN ARC SERVICE.

Plants having engines with horse-power of—	Private plants.				Municipal plants.			
	Number reporting.	Average price to private users.	Number reporting.	Average price to municipality.	Number reporting.	Average price to private users.	Number reporting.	Average cost to municipality.
Under 50	1	$0.1028	3	$0.1258	1	$0.0815	6	$0.0719
50 and under 75	19	.1146	22	.0861	10	.1100	18	.0631
75 and under 100	18	.0986	21	.0868	10	.0822	30	.0499
100 and under 125	23	.0940	34	.0770	15	.0776	36	.0423
125 and under 150	17	.0892	24	.0798	12	.0684	31	.0376
150 and under 200	38	.1291	47	.0846	16	.0862	29	.0397
200 and under 300	58	.1075	72	.0710	31	.0821	42	.0451
300 and under 400	40	.0906	40	.0659	11	.0783	24	.0408
400 and under 500	27	.1000	33	.0657	3	.0556	9	.0430
500 and under 750	57	.1046	54	.0696	6	.1139	7	.0406
750 and under 1,000	38	.0939	35	.0629	1	.0833	4	.0337
1,000 and under 1,500	31	.1056	32	.0698	4	.0521	3	.0418
1,500 and under 2,000	15	.1299	20	.0709	1	.1126	2	.0233
2,000 and under 3,000	18	.1157	18	.0664	....	....	2	.0381
3,000 and under 5,000	9	.1202	11	.0514	1	.0380	1	.0264
5,000 or over	10	.1400	12	.0596	....	....	....	....

This table shows for private plants and for municipal plants, subdivided according to the groups shown in the general tables, the average price of service to private users per kilowatt hour and the average price charged to the municipality per kilowatt hour by private plants as compared with the average cost to the municipality of arc lights furnished for the municipal service by municipal plants. Taking up first the average price charged per kilowatt hour by private plants in each group, and comparing it with the average price charged to private users per kilowatt hour by municipal plants, it is seen that in all of the groups subject to comparison except one the average price charged by municipal plants is smaller than that charged by private plants. As regards the arc lighting used in the municipal service, it is seen that in every group subject to comparison the average price per kilowatt hour charged to the municipality by private plants for its arc lighting service is greater than the average cost per kilowatt hour to the municipality of the same service when furnished by its own plant.

As regards the incandescent lighting service, as has been stated, it was found impossible to reduce the product to a uniform basis, and for this reason a series of tables has been made, each of which includes all of the prices found in the general table based on the particular unit to which each of the summary tables refers.

The first table shows the average price per lamp per year charged in the unmetered incandescent service. In this table have been included all the prices shown in the general table for the unmetered incandescent service, whether the price was given as per lamp per month or per lamp

per year, the prices given per lamp per month having been reduced to the basis of 16 candle-power lamp per year. The table follows.

AVERAGE PRICE PER 16-CANDLEPOWER LAMP PER YEAR CHARGED IN UNMETERED INCANDESCENT SERVICE.

Plants having engines with horse-power of—	Private plants.				Municipal plants.			
	Number reporting.	Average price to private users.	Number reporting.	Average price to municipality.	Number reporting.	Average price to private users.	Number reporting.	Average cost to municipality.
Under 50	3	$5.23	3	$5.65	3	$8.09	4	$ 8.63
50 and under 75	25	7.50	16	8.40	11	5.16	9	10.09
75 and under 100	25	6.20	21	10.21	20	5.35	14	6.97
100 and under 125	43	6.19	30	8.12	35	4.62	23	5.08
125 and under 150	31	6.32	22	7.76	20	4.57	22	4.58
150 and under 200	46	7.02	39	10.06	24	5.33	26	5.97
200 and under 300	60	6.42	50	10.55	28	5.61	30	4.45
300 and under 400	25	5.89	27	11.11	13	8.19	15	4.34
400 and under 500	21	7.90	22	12.76	3	3.11	7	5.56
500 and under 750	31	7.32	32	10.28	5	2.56	6	4.36
750 and under 1,000	20	7.56	21	10.31	....	....	3	2.91
1,000 and under 1,500	13	6.97	20	11.98	2	6.00	4	3.32
1,500 and under 2,000	5	5.88	6	8.49	1	3.93	2	3.77
2,000 and under 3,000	3	11.53	8	10.82	....	....	1	11.44
3,000 and under 5,000	2	10.64	3	7.40	1	3.63	....	....
5,000 or over	3	4.46	3	11.67	....	....	....	....

There is shown in the preceding table for all plants reporting as to the facts, under each of the groups adopted in the general tables, the average price charged per lamp per year by private plants to private users and to the municipality, and also the average price charged by municipal plants to private users and the average cost to the municipality of its own service. Taking up first the average price charged to private users, it is seen that in all of the groups except two the average price charged by the private plants is considerably in excess of that charged by the municipal plants; while, so far as the electricity used for municipal purposes is concerned, it is seen that, with the exception of three groups, the average cost per lamp per year to the municipality of its own service is very much smaller than the price charged by private plants to the municipality for a similar service, this cost in some cases being less than half the price charged by private plants.

The next three tables show average prices of the incandescent service per kilowatt hour, per lamp hour, and per ampere hour to private users in plants reporting prices on the basis of these units. The cost of production is not considered here, and for this reason the electricity furnished by municipal plants for public use is not included. The table showing the average price of the incandescent service per kilowatt hour to private users in plants reporting follows.

AVERAGE PRICE OF INCANDESCENT SERVICE PER KILOWATT HOUR TO PRIVATE USERS.

Plants having engines with horse-power of—	Private plants.		Municipal plants.	
	Number reporting.	Average price per kilowatt hour.	Number reporting.	Average price per kilowatt hour.
Under 50	1	$0.2000	2	$0.1250
50 and under 75	9	.1667	4	.1650
75 and under 100	7	.1371	11	.1264
100 and under 125	16	.1559	23	.1173
125 and under 150	15	.1466	13	.1146
150 and under 200	35	.1552	24	.1160
200 and under 300	28	.1646	27	.1132
300 and under 400	32	.1582	11	.1162
400 and under 500	26	.1526	2	.1250
500 and under 750	34	.1497	3	.0800
750 and under 1,000	32	.1589	1	.0800
1,000 and under 1,500	25	.1538	3	.1083
1,500 and under 2,000	13	.1555	1	.0500
2,000 and under 3,000	10	.1253	....	....
3,000 and under 5,000	8	.1406	1	.0450
5,000 or over	9	.1536	....	....

This table shows for the plants reporting the price per kilowatt hour, in each of the groups adopted in the general tables, the average price per kilowatt hour charged by private plants and the average price charged by municipal plants. Taking up the figures, it is seen that in all of the groups the average price charged per kilowatt hour by municipal plants is less than that charged by private plants.

The following table shows the average price of the incandescent service per lamp hour to private users in plants reporting:

AVERAGE PRICE OF INCANDESCENT SERVICE PER LAMP HOUR TO PRIVATE USERS.

Plants having engines with horse-power of—	Private plants.		Municipal plants.	
	Number reporting.	Average price per lamp hour.	Number reporting.	Average price per lamp hour.
Under 50	....	....	....	....
50 and under 75	1	$0.0100	2	$0.0057
75 and under 100	3	.0100	4	.0060
100 and under 125	6	.0096	2	.0045
125 and under 150	2	.0113	6	.0044
150 and under 200	7	.0093	6	.0055
200 and under 300	8	.0092	10	.0068
300 and under 400	3	.0098	....	....
400 and under 500	5	.0090	3	.0067
500 and under 750	6	.0081	....	....
750 and under 1,000	2	.0090	....	....
1,000 and under 1,500	7	.0096	....	....
1,500 and under 2,000	1	.0075	....	....
2,000 and under 3,000	2	.0067	....	....
3,000 and under 5,000	1	.0100	....	....
5,000 or over	4	.0081	....	....

This table shows for the private and municipal plants reporting, in each of the groups adopted in the general tables, the average price per

lamp hour to private users of incandescent service. An examination of the table shows that this average price is less in every group containing municipal plants than the corresponding group of private plants.

The last of this series of tables shows the average price of the incandescent service per ampere hour to private users in plants reporting.

AVERAGE PRICE OF INCANDESCENT SERVICE PER AMPHERE HOUR TO PRIVATE USERS.

Plants having engines with horse-power of—	Private plants.		Municipal plants.	
	Number reporting.	Average price per amphere hour.	Number reporting.	Average price per amphere hour.
Under 50	....	....	....	....
50 and under 75	1	$0.0075	3	$0.0055
75 and under 100	3	.0106	1	.0050
100 and under 125	7	.0083	4	.0073
125 and under 150	2	.0125	2	.0071
150 and under 200	7	.0083	7	.0058
200 and under 300	11	.0105	8	.0066
300 and under 400	6	.0080	4	.0113
400 and under 500	2	.0085	2	.0063
500 and under 750	17	.0100	2	.0075
750 and under 1,000	8	.0077	1	.0075
1,000 and under 1,500	4	.0097	....	....
1,500 and under 2,000	4	.0106	....	....
2,000 and under 3,000	6	.0099	....	....
3,000 and under 5,000	1	.0050	....	....
5,000 or over	3	.0088	....	....

This table is similar to the two preceding, and shows for the private plants and the municipal plants reporting the average price per ampere hour charged to private users in each of the groups. The table shows that the average price is less in the municipal plants than in the private in all of the groups in which comparison could be made except one. It should be borne in mind that so far as municipal plants are concerned the three summaries immediately preceding necessarily show prices only for electricity sold, the quantity furnished for the public service being excluded.

Table XI.—Prices (private plants) and cost of production (municipal plants) of arc lighting per lamp per year (see tables).—This table deals with arc lighting alone and, as has been stated, contains data relating to the same plants for which arc light prices per kilowatt hour were furnished in the preceding general table. In this table the prices are given per lamp per year instead of per kilowatt hour, the table having been made for the purpose of furnishing prices on a per lamp per year basis for those who desire to compare the prices of the arc service on this basis. It should be noted, however, that this table does not show as many arc lamps as are shown in Table X, as it was deemed advisable to omit all lamps on a strictly meter service and those in irregular

service, because it was believed that these could not fairly be put in comparison with other lamps. This table shows, for the lamps furnished for private service, the type of lamp, number of lamps, watts per lamp per hour, basis of price, hours of service per year, and price per lamp per year; while for the lamps used in the municipal service it shows the type and number of lamps, watts per lamp per hour, basis of price, hours of service per year, and price when bought from a privately owned plant or cost when furnished by a municipal plant per lamp per year. Considerable variation in the prices of lamps of the same type, and burning the same number of hours, is found not only in comparing the prices for different plants, but in comparing prices in the same plant, and is due very often to the conditions of the contract. Generally a single lamp or small number of lamps is furnished at a greater price per lamp than a large number. In addition to this, special prices are sometimes made in order to compete with gas companies furnishing a service in the same locality. It will be seen that by far the greater number of the arc lamps shown in this table are used in the municipal service. Of this number almost all are used for street lighting, but a small proportion being used for other purposes. Of the arc lamps in private service, on the other hand, practically all are used for purposes other than street lighting.

In order to bring the figures in this table into a more compact form for purposes of comparison, the following summary table has been made, showing the average price per lamp per year of arc lighting grouped according to the hours of service rendered per year:

AVERAGE PRICE PER LAMP PER YEAR OF ARC LIGHTING, BY HOURS OF SERVICE RENDERED.

Hours of service per year.	Private plants.				Municipal plants.			
	Number of lamps.	Average price per lamp per year to private users.	Number of lamps.	Average price per lamp per year to municipality.	Number of lamps.	Average price per lamp per year to private users.	Number of lamps.	Average cost per lamp per year to municipality.
Under 500	197	$ 43.74	2	$ 11.25	11	$ 31 64	....	....
500 and under 750	335	54.64	3	72.00	75	44.19	213	$ 18.10
750 and under 1,000	259	58.31	20	37.50	51	39.18	46	52.32
1,000 and under 1,250	1,938	69.87	672	58.13	85	54.98	477	27.49
1,250 and under 1,500	2,226	79.20	327	90.78	362	59.09	433	55.78
1,500 and under 1,750	3,666	98.13	520	71.56	136	47.99	671	36.20
1,750 and under 2,000	3,001	76.08	966	67.76	345	52.48	677	37.61
2,000 and under 2,250	4,896	101.16	7,382	81.51	580	63.18	5,141	39.73
2,250 and under 2,500	1,535	117.88	1,649	86.17	26	67.99	761	52.57
2,500 and under 2,750	831	93.81	2,262	85.05	52	69.50	1,763	57.17
2,750 and under 3,000	205	76.86	129	74.90	12	47.50	1,198	43.76
3,000 and under 3,250	211	63.41	4,023	105.80	54	60.85	2,173	45.75
3,250 and under 3,500	156	159.32	414	94.12	22	50.00	227	34.66
3,500 and under 3,750	436	91.42	2,854	93.99	31	84.52	1,006	54.71
3,750 and under 4,000	1,936	123.90	21,246	100.60	147	129.95	5,264	63.57
4,000 or over	2,044	149.54	25,636	101.97	73	65.26	2,669	58.56

The entire number of lamps furnished for service by private plants and by municipal plants is in this table grouped according to the number of hours of service rendered per year. This element of hours of service rendered influences prices more considerably perhaps than any other condition of service, and for this reason it is selected as the basis of the groups into which the lamps furnished by the various plants have been divided. For the lamps under each of these groups is shown the average price per lamp per year to private users and to municipalities as charged by private plants, the average price charged by municipal plants to private users, and the average cost per lamp per year to the municipality of its own service when furnished by a municipal plant.

Taking up the prices to private users, it is seen that in all of the groups except one the average price charged per lamp per year is smaller in municipal plants than in private ones. Comparing the columns showing the average price charged by private plants per lamp per year to the municipality and the average cost per lamp per year to the municipality of lights furnished by municipal plants, it is seen that in all of the groups except one the cost per lamp per year of lights furnished by municipal plants is smaller than the price charged per lamp per year by private plants to the municipality for the lights used in municipal service.

H. W. MACROSTY

Of the Fabian Society

ENGLISH STATE SOCIALISM

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"Competition generally ends in combination; and that can now be carried out in the form of a 'ring' or 'trust,' on a scale and with a degree of perfection of which previous generations had no conception." Such is the remarkable conclusion to which the *Times* came in a leader on the shipping rings, having banished the old ideas of political economy to Saturn. How then are we to fight the trusts? The "not very hopeful

course" which the same writer suggests is "to meet as far as possible combination by combination, to multiply the agencies against which the 'ring' must fight, until they are too many and strong to be mastered." The German newspaper proprietors are starting paper-mills of their own in consequence of the heavy prices charged by the syndicate of paper-makers—an experiment which will be watched with much curiosity. Supposing this plan to be carried to a successful issue on a large scale, the country would be covered by a network of combinations, each strong enough to prevent mutual plundering. The united groups of manufacturers would be able to hinder extortion on the part of the extractional industries of coal and iron, and to compel the organisers of transport to charge only reasonable rates; but there would still be no power to regulate retail prices. The consumer would still be perfectly helpless. He is told to look to independent competition as the means of keeping prices at a proper level; but the "combine," by charging low rates and looking to a large turnover for its profit, could create a state of things in which the people would be politically serfs and yet fresh capital would not be tempted to come in. Even if prices were maintained at a high level, the prospects of a new competitor would not be brilliant, for he would have to face the hostility of a company already in possession of the field, fully equipped and well organised. The mere threat of a war of rates by the Coats Company brought the English Sewing Cotton Company to terms, although the latter had a capital of two and three-quarter millions; and not every new undertaking could command such an amount of money for a risky speculation. To fight the shipping rings would mean the creation of a new mercantile marine. The power of the purse can be used to buy out as well as to starve out a rival, and few men of business are so philanthropic as to prefer the bankruptcy court to being merged with a formidable opponent. The National Telephone Company bought up all the competing companies, and the shipping rings have either driven away the small lines which presumed to contest their monopoly or have compelled them to sell out.

As little can any reliance be placed on foreign competition. Capital is international, and combinations started in one country soon stretch out friendly hands to similar organisations in other lands. The alliance between the Coats Company, the English Sewing Cotton Company, and the American Thread Company is a good illustration of what we may expect to be the next stage in industrial development, the exclusion of competition from the outside after it has been eliminated from the in-

side. Several other British combinations possess factories abroad, and in this way a tendency towards the establishment of equivalent prices everywhere is stimulated. H.M. Consul at Düsseldorf, in reporting on the results of the Rhenish-Westphalian Coal Syndicate, adds: "The German coal-owners are long-sighted enough to see that it is desirable in the mutual interests of both that an English coal syndicate should be established on the same lines as have proved so successful in this district, for the simple reason that a reckless competition between them, *i. e.*, between England and Germany, has an injurious effect on both. Of course, in England, Wales, and Scotland co-operative action is rendered difficult by the number of coal districts to be united, but it has got to be done in one form or another." Foreign competition in some cases may even overmaster the home producers and compel them to dance to a tune played abroad. This has been the fate of the Scottish paraffin-oil industry, where millions of money have been lost, although the founders made their fortunes. The Standard Oil Company with a cheap "low-flash" oil drove the higher-priced paraffin out of the market, and forced the Scottish makers to seek a scanty profit by turning a vast amount of ability and science to the utilisation of waste products like paraffin wax and lubricating oils, whose prices are fixed at the will of the great monopoly.

Not much can be expected from the trade unions in the way of fighting monopoly; it will probably require all their energies and resourcefulness to maintain their standard of life against power used brutally as at Homestead, or against more subtle assaults in the introduction of machinery. It was an easy matter for the cotton-spinners to defeat the "cotton corner" by offering to work short time so that the employers might postpone their ordinary purchases and prevent prices from rising, but they would find a different foe in a corporation including all the master spinners—a combination which has been debated lately. Where the workpeople federated themselves with the employers, as in the Birmingham "alliances," on the basis of being allowed to share in the plunder of the consumer, or on the basis of a limitation of output, as the Welsh coal-miners urged, we would have the most dangerous form of combination. It is the business of trade unions to look after the interests of the workpeople, about which other people usually concern themselves only in a spasmodic manner, and it is folly to ask them to undertake additional labours. If the consumer wants to be protected he must do his own protecting. To some extent he does that already through his co-operative societies, and where

they exist their members are secure from the yoke of retail monopolies. The ordinary reason for starting a store is the desire to be free from the exactions of the shopkeepers, and a similar reason has caused the stores to undertake the production of certain commodities of universal domestic demand. Refusal to join in the "flour corner" cost the English Wholesale Society over £20,000, but it killed the "corner." Flour-milling, however, is the only industry which has been undertaken co-operatively on a large scale, though successful beginnings have been made in many others. Even if we suppose all the retail business of the country to be carried on by co-operative stores, we cannot expect that they would undertake manufactures except of goods in domestic use, since for these alone would they have an ascertainable market. The clothing, food, and furnishing trades might be socialised in this way, and the building trade so far as the stores built houses by their own workmen for their members; the textile trades for home production might also conceivably be included. But all the production for export, the iron, steel, and engineering industries, the transport industries, agriculture, and mining would remain outside the scope of co-operation. Perhaps an exception might be made in favour of agriculture and mining, for, although the results of previous experiments have not been brilliant, the English Wholesale Society has a roseate prospect of success on the Roden estate, and several northern societies, including the large Leeds Society, have for some time been considering the establishment of a co-operative colliery in Yorkshire. There are some further limitations of co-operative effort. The great strength of the movement is in the highly organised trade union districts of factory workers, where wages are reasonable and employment is fairly permanent. Among the very poor everywhere, the agricultural labourers, and the workers in large towns who shift about from place to place following their work, co-operation progresses very slowly, despite the vast amount of energy which is expended on propaganda, and these districts must approximate more closely to the factory districts in character before any signal success is achieved. Another limitation consists in the nature of co-operators themselves. Very many members do not look upon the movement as part of a great social reconstruction, and limit their interest to "divy-hunting" as an automatic system of thrift. The consequence is that committees are forced to attend more to the half-yearly balance-sheet than to the aims of the movement, and large purchases are made from private firms which sell a few pence cheaper than co-operative concerns. The manu-

facturing activity of the Wholesale Societies is therefore strictly circumscribed by the competition of the private undertaker, and the public utterances of their representatives are a constant appeal to "buy, buy, buy!" The very shrewd and cautious men who are at the head of the co-operative state do not believe in the speculative construction of factories or in the locking-up of very large sums of money in stone and iron unless an assurance is given of a large and steady market for the produce. The Broughton cabinet-making factory was for a long time run at a loss owing to insufficient support from the societies, and there is not much desire to repeat the experience. It would seem as if the newer generation of co-operators had lost some of the eager enthusiasm of their forefathers; but the interest which the housing question has aroused during the last year shows that only a more persistent educative effort is required to awaken the old fervour.

When full value has been allotted to what may be expected from voluntary attempts to withdraw production from private control, there still remains a wide field for the activity of that broader federation of individuals which we call the State. Nor have the opponents of trusts been slow to appeal to the legislative chambers for assistance. Unfortunately they have not sought to control the economic evolution, but to destroy it in the interests of competing individual traders, seeking to restore the waste of energy which combination prevents. Very many of the States of the American Union have passed laws directed at the formation of organisations of the original "trust" kind, which were characterised by the deposit of stock in the hands of governing trustees; but though these measures have been successful in destroying the outward form, they have left the inward reality untouched. The Standard Oil Company was dissolved in this way in 1892, but the monopoly of petroleum went on unchecked. Neither the enforcement of the common law against agreements "in restraint of trade" nor the invention of new penalties can prevent a private understanding among manufacturers, or the fusion of a number of firms into one undertaking, or the crushing-out of small concerns by one large business. They can only hamper legitimate trading, like the Texas Anti-Trust Law, which, being specially directed against insurance companies with an arrangement for common tariffs, is driving that form of business out of the State. Owing to German competition and high prices affecting all industries using iron, a law was passed in Austria in 1899 prohibiting the formation of an iron "ring"; but it has never been enforced, and we have the un-

healthy spectacle of fictitious laws which bring law-making into contempt. The great bulk of Russian coal is produced by some score or so of owners, and the action of syndicates during 1899-1900 has been so mischievous in restricting output and raising prices that, according to a Foreign Office Report (No. 523, Commercial Series), "stern administrative measures" have had to be taken. "At Warsaw wholesale dealers have been summarily ordered, under heavy penalties, not to keep prices above 1r. 15c, the korsec of 6 poods, while, it is said, seventeen of the largest dealers have been placed under police supervision." To Russia, therefore, must go the credit of the only effective anti-trust action; but the same report, it is fair to add, concludes that these measures and the temporary remissions of import duties are only "temporary expedients not touching the heart of the matter."

Private monopoly is a public danger, and yet it cannot be undone by law; nor if it could would any economist recommend that the community should abandon the most efficient method of production for a worse. The problem is, how to secure the benefits of combination without its disadvantages, and to this there is only one solution, the public ownership of monopolies. An arguable case can be made out for public ownership as against competition, but the consumer—and after all, consumers control politics—will not concern itself much about the evils of competition when employers are "good," if an efficient service is assured to him thereby. But monopoly is a very different matter. A people which has been trained by centuries of political freedom instinctively hates the domination of a few individuals; it may tolerate, grumblingly, the privileges of a single monopoly, like the railways, but monopolies in every branch of industry are at once recognised as dangerous. When a monopoly becomes collective property its character is entirely changed. Given a good system of administration and effective parliamentary control, and arbitrary conduct, which is the essence of tyranny, is impossible. Undue raising of prices or unjust treatment of employees would cause a political reaction against the government responsible, and would therefore be avoided. Every person with a grievance would, being a voter, be able to secure a hearing of his case before the highest court of appeal in the land, and every real source of complaint would be remediable, even if slowly. Compare the Post Office with the railway companies before the institution of the Railway Commission. In the former case, notwithstanding the want of sufficient business ability and habits among the higher officials, postal rates have

been lowered and the position of the lower employees bettered; while in the latter instance the complaints of traders were flouted and the grievances of railway servants neglected. It is not pretended that the Post Office is in all respects a model institution; that it cannot be so long as the Treasury persists in regarding it as above all a revenue-producing and tax-saving machine, instead of one of the great arteries of commerce. But that so much has been possible under the present *regime* is indicative of developments which may ensue when the business of the community is really conducted on business lines.

The great public advantages of monopoly are that by eliminating competition it prevents over-production and crises, and restores stability to industry and permanence to employment. While monopolies are in private hands, the desire to make illicit profits by speculative transactions on the stock and produce exchanges acts as a disturbing factor which would disappear under communal ownership. Even under existing conditions the transfer of one industry from private to public ownership has a regulative effect outside its own immediate sphere. By a law of 1885, the Swiss Federal Government has had, since 1887, a monopoly of spirituous liquors. The direct object of the law was to check the consumption of deleterious drinks, especially those distilled from potatoes, and a very large measure of success has been attained, while at the same time the results to the federal and cantonal treasuries have been highly satisfactory. The good effects have not stopped there. Previous to the creation of the State monopoly there were fourteen hundred and fifty distilleries, which were all abolished and replaced by seventy establishments allowed only to use native produce, the alcohol manufactured by them being bought by the State officers at rates enabling remunerative prices to be paid to the farmers. "The abolition of existing distilleries, which for the most part were either too large to be supplied with raw material grown in the neighbourhood, whereby foreign importation was encouraged, or too small to serve as a market for native produce, and the substitution of distilleries proportionate to the capacity of the district where their establishment was thought advisable, has benefited agriculture by affording a ready market whose demands are commensurate with the possible supply; while the refuse material forms a valuable manure, and, owing to the proper distribution of distilleries, in sufficient quantities to meet the local requirements, whereas previously the supply was either in excess or inadequate, without any existing organisation to distribute it where needed."

The applicability of State enterprise to any industry will depend on a number of circumstances, varying according to time and place. The chief of these is the degree of organisation to which the industry has attained. In conducting any branch of manufacture the State will certainly proceed on the co-operative principle of equating the supply to the ascertained demand, and the ease with which this can be done depends to a large extent upon the degree to which private ownership has already concentrated the management. Where the production of an article in general and steady use is in question, and one or two large companies have a monopoly of the trade, the transfer can be brought about with very little disturbance of the machinery. Some industries have already reached this stage of evolution; for example, Professor Ashley says, "We might even add that, in the case of the Standard Oil monopoly, the development has already reached a point at which, on the purely economic and administrative side, there could be little objection to the Government taking over the business—if only there were a Government politically capable of the task." If some of the new British combinations which have begun operations with 80 or 90 per cent. of the production in which they are engaged under their control continue to extend their operations, or even to maintain their position, we shall be able to include them in the same category. In France tobacco and matches are already nationalised, but for fiscal purposes, and are consequently run on the vicious principle of extracting the largest amount of profit for the smallest possible return. On the whole, it is plain that at any given time the industries of a country may be arranged in a rough kind of order according to their organisation, and in that order it is most likely that the State will seek to communalise them. At the head will be the most highly organised industries, and last of all will come such disorganised trades as the "home industries," unless they are previously legislated out of existence, or those which from time to time are thrown into disorder by irregular caprices of fashion. Each successive step will be taken experimentally, and no move will be made which is at all likely to involve the community in pecuniary loss unless other counterbalancing advantages are gained. It is not conceivable, for example, that the silk or velvet industries, which are inflated or depressed according to the irresponsible decrees of the fashionable world as to what is or is not to be worn, should be nationalised before the already highly concentrated cotton or dyeing industries.

The organisation of an industry under State management would

be very much what it is at present under, say, the Standard Oil Company, or, still more closely, under the Co-operative Wholesale Societies. Through the retail selling departments in the various centres the trade of, say, the previous quarter would be ascertained, and, the rate of growth being known from the comparative statistics of successive periods, the probable demand for the ensuing quarter could be calculated. Arrangements for production would be based on this information, and could be from time to time corrected according as intermediate reports disclosed any abnormal increase or diminution of demand. This method is in everyday practice among hundreds of co-operative societies as well as in a countless number of manufacturing businesses standing in close relation to the retail trade. The government of an industry would also proceed on similar lines to those which individual ability has created. The most striking change would be the substitution of a State department for the board of directors, or rather, perhaps, the department would correspond to the managing directors, while the general board of men of wide business knowledge who function on many such boards and take part in the direction of many companies would be represented by Parliament. We would thus have in combination men of specialised expert knowledge, men with a general acquaintance with the business world, and men whose duty it was to safeguard the general interests of the community, all engaged in controlling the several national industries. Beneath the supreme management everything would go on much as at present: there would be the same severance of staffs according to their duties, the same hierarchy of secretaries, managers, sub-managers, foremen, and so on. Half the criticism which is directed at the collectivisation of industry would fall to the ground if it were clearly understood that it necessitates not so much changes in organisation as an alteration in the aims to which that organisation is to be directed. Writers of utopian fiction, with their dreams of industrial armies disciplined in military manner, of successive grades of workers electing each other by secret ballot and one man one vote, or of an absence of order being order's first law, have done much to discredit the cause of collectivism. The sober practice of democratic working-men gives no scintilla of support to any such topsy-turviness. There is no democracy in the world so free and equal as a co-operative society; and that democracy having once elected its committee of management for the allotted period, leaves the whole administration in its hands. The committee conducts the business, and engages, promotes, or dismisses the work-

people. Representative government is the last word in industrial as in political democracy.

Sir Robert Peel in a memorable phrase once spoke of "the torpid hands of the State;" Professor Ashley demands that the Government which takes over the Standard Oil Company shall be "politically capable of the task." The two phrases are closely connected. The hands of the State were torpid so long as the State was served by an incompetent bureaucracy which jobbed and muddled and idled to an incredible extent. Forty years of good administration have to some degree eradicated the memories of the Circumlocution Office, but of late the public has been driven to conclude that much reform is still required. The first necessity is that an administrative staff should be trained for the functions which it has to perform; the second is that every man must bear a definite share of responsibility—there must always be "some one to hang." These two conditions are necessary for efficiency even in a department where all the work is clerical, and they are absolutely indispensable wherever anything in the nature of production is concerned. What is required is not so much technical acquaintance with the particular industry in question—that can be supplied by the manufacturing staff—but general knowledge of business affairs and a keen sympathy with the needs of the section of the community served by the department. Want of these qualities has made Government departments averse to innovation and slow to suit their methods to the changing requirements of the business world. As a matter of fact the public service, as we know it to-day, has not been organised to meet demands which have only been made upon it within the last couple of decades or so. Its traditions are derived from an obsolete political philosophy, and retain much of the individualism and feudal separation of classes which have elsewhere disappeared. Before nationalisation of industry can be carried out to any serious extent, the methods of administration must be revised, and the higher officials must be drawn less from the universities and more from the same classes which at present run the industries of the country. Whether this will be done depends on the political capacity of the Government and of Parliament, and also, it may be added, of the electorate. Politics must come to mean the supervision of the business of the country, and cease to be a party struggle regarded as an avenue to place or social position. The greatest obstacle to public control of industry is the want of political capacity on the part of our legislators. The House of Lords having before it a Com-

panies' Bill, proceeds to strike everything out of it which might deter titled guinea-pigs from becoming directors, heedless of the fact that this is exactly the result which the public, instructed by the Hooley revelations, desired to attain. For a brief moment Parliament was shocked by Lord Salisbury's denunciation of Treasury control of public affairs, but no one remembered that exactly the same charges had been made and suggestions for reform put forward by Sir Robert Giffen in his evidence before the Royal Commission on Civil Establishments in 1888. Reform of the personnel of Parliament must precede any broad alteration of our industrial system.

So far we have spoken simply of "the State," but as a matter of fact "the State" in this country is for administrative purposes a series of authorities related to each other in a complex manner. From one point of view the interest of all citizens in all part of the country may be regarded as identical; bad government in one locality is a danger to the whole community, and no nation can tolerate an Alsatia within its boundaries. Such considerations led the late Sir Edwin Chadwick to that policy of centralisation which he advocated with so much pertinacity, and which has left so deep a mark on all the legislation brought forward under the ægis of his authority. Its advantages are many and conspicuous, but the necessity of providing for the varying needs of different localities, and the desirability of harnessing local knowledge and local patriotism to the administrative plough, have prevailed in extending the principle of the division of labour to government. We have consequently a series of local authorities rising one above the other, with wider spheres of activity, until we end in the supreme authority of Parliament, which is charged with the functions of providing for the common needs of the nation and of harmonising the activities of the local governing bodies. The latter of these objects is pursued in a variety of ways. In poor-law matters a strict conformity to rules laid down by the central government is enforced; in educational matters conformity to similar rules is induced by grants of money dependent upon the attainment of a certain standard of excellence. The enforcement of the factory laws depends upon local tribunals, but the supervision of the regulations and the conduct of prosecutions is in the hands of inspectors attached to the Home Office. Grants of money enable the central government to exert a good deal of pressure upon local authorities; municipalities may lose their police grant if the force is not in a proper state of efficiency, and London borough councils may be deprived

of the "equalisation grant" for neglect of their public-health duties. Recalcitrant school boards or boards of guardians may be dissolved and their functions transferred to commissioners; one local authority may be empowered to act for another, as the London County Council on default by a metropolitan borough council; or factory inspectors may be directed to carry out the law in respect to workshops when municipalities neglect it. By the development of one or other of these methods the central government can exercise a still greater control over any extension of local activity. General laws, codes of regulations can be drawn up, on obedience to which might depend the grant of public money sufficient to bring up the standard of local comfort and efficiency to the general level. At present a large share of the produce of the death-duties is allocated to local authorities without any return being required, and this might very well be altered.

Industries may be divided into local or national according as they respond to local or general needs. In any scheme of collectivisation the former would necessarily come under the management of the local authorities, the latter under the central government. Until we examine the details of municipal administration we are apt to ignore the extent to which we have already proceeded in municipalisation. The doings of the central government get reported in all the newspapers, but municipal politics interest only a limited circle of people. A brief review will therefore be instructive, and all the more because the developments to be described have not been followed out in pursuance of any definite political philosophy, but because each step as it was taken was found to be advantageous to the citizens. The philosophy has come afterwards to correlate the different political phenomena.

When municipal corporations were reformed, there was no suspicion in the mind of Parliament or of the municipalities that the management and ownership of public services would come to form the chief part of their activity. The Act of 1835 was passed in order to create bodies which would be able to control the new police force. Lighting and water supply were left to be provided by private companies, and even sanitation was considered to be the concern of the individual householder. The cholera, however, proved a wonderful educator, and gradually drainage, paving, and street lighting came to be regarded as the primary duties of municipalities. The provision of a sufficient supply of pure water was seen to be necessary to the public health. But gas and water companies had fixed themselves tightly on the towns, and it

became repugnant to the moral sense of the community that such necessaries of life as light and water should be the monopoly of private individuals, especially when the supply was in many cases seriously deficient. Thus began the "gas and water socialism" of our local authorities. The municipilisation of electricity was a natural corollary to municipal gas. Public baths and cemeteries were found to be necessary to the care for the public health. To-day the capital expended in England and Wales on water-works amounts to nearly forty-eight millions and a half, on gasworks over twenty millions, on baths a million and a half, on cemeteries over a million, on electric lighting nearly three millions and a half. Works for the disposal of sewage also became a public necessity, and are responsible for the expenditure of a large amount of money. Some of these undertakings are of a gigantic character. Glasgow derives its water supply from Loch Katrine at a cost of three millions; Liverpool has spent two million one hundred thousand pounds in converting a Welsh valley into a lake and bringing water from it through a canal seventy-seven miles long; Manchester has secured an abundant supply from Thirlmere for an expenditure which will run up to four or five millions; and Birmingham is in course of expending nearly seven millions in introducing a supply from Wales.

Towns exist in order that, amongst other reasons, business may be carried on in them, and the citizens have naturally, therefore, set about to provide facilities for conducting business. The care of the streets is an elementary part of a corporation's duties, and as towns grew in size it was felt that the provision of cheap and comfortable means of transit was equally within the scope of municipal activity. This service was also at first entrusted to companies, but with an important difference. No municipality can run a municipal water or gas supply in competition with a company already in the field; and if it is proposed to buy out the company, a private Act of Parliament must be obtained, and heavy compensation paid. When the Tramways Act of 1870 was passed, power was given to municipalities obtaining a provisional order from the Board of Trade to construct tramways, and no private line could be built without the consent of the local governing body. But no municipality could work the tramways it had built; it must lease them to a company for twenty-one years, at the expiry of which time they could be taken over by the municipality at their "then value" if built by the company, free of all compensation for compulsory

sale, and worked by the local authority. So great an objection existed in Parliament to municipal working of tramways that down to 1896 a standing order prohibited the introduction of any bill having the object of empowering local authorities to run tramways. The change in the attitude towards municipalisation is also shown by the Electric Lighting Acts of 1882 and 1888, which from the beginning permitted the fullest freedom to municipal action. The capital invested in municipal tramways is about three millions and a quarter. The provision of a ferry service on rivers is closely akin to the provision of bridges, and Glasgow and Birkenhead, for example, own ferry-boats, while London has a free ferry at Woolwich. All trade used to be done in markets, and the city market is probably the oldest municipal institution. Piers, quays, and harbours are equally necessities of trade, and together with markets they account for some nine and a half million pounds. Municipal slaughter-houses come under the category of trade facilities, but the public health is the real reason for their institution. There is, however, no doubt about the classification of the test-house for wool maintained by Bradford. Many of the pleasure towns contribute to the attractiveness which is their main support: the seaside towns by owning piers; Chester and Doncaster by owning racecourses; Bath, Harrogate, and Leamington by maintaining the medicinal springs and their appurtenances; Blackpool by spending large sums in advertisements.

Nowhere has private enterprise so completely broken down as in the supply of houses for the people. The combination of monopoly in urban land and perfect freedom to the builder has ended in jerry-built houses and overcrowding. The failure is indisputable, it is openly admitted by every one; such facts as that a hundred and twenty thousand people in Glasgow live in one room per family proclaim it aloud. Nor is there any doubt as to the remedy. Since Glasgow began its great clearance scheme in 1866, it has become every year more apparent that the municipalities alone are capable of undertaking the enormous task of housing. Not only must houses be built for the increase of population, but also for the people to be cleared out from the slums we have inherited from private enterprise. The central authority in London has spent two and a half millions in clearances and housing, and at least ten millions have been spent in the United Kingdom on these objects. The real difficulty is how to build fast enough, and how to rehouse the people expelled from the slums; for at present the sad fact is that they go to create other slums, while the new houses are inhab-

ited by a higher grade of workers. When it is fully recognised, and the law is based on that recognition, that each town or village or country district is responsible for the proper housing of the people resident therein, then but not till then will it be possible to wipe away this blot on our civilisation. Owing to the great lack of good sanitary houses, the Government might grant to a district for additional building a sum equal to what the local authority was spending. Certain consequences will necessarily follow. Each town must be its own landlord. The steady pouring of unearned increment into the pockets of the proprietors of urban lands must cease; land values must be municipalised by taxation. Further, each town must become its own builder. Municipalities have discovered other monopolies besides the "natural" ones of gas and water; it was a "contractors' ring" which first caused the London County Council to start its much-abused Works Department. Whatever defects have come to light while municipal building has been in its experimental stage, they can be more than matched by the defects of contract work; while nothing worse in bricks and mortar is conceivable than the rows of "desirable suburban residences" run up to sell for the creation of ground-rents. Combining municipal housing with a cheap or free service of communication by tramway or railway, we can look forward to the relief of congested town districts by the creation of villages or small towns in the surrounding country, thereby indirectly contributing something towards a solution of that other great problem of modern life, the depopulation of the rural districts.

All of these branches of activity thus lightly sketched originate from the failure of private enterprise in the shape of private monopoly, from insufficient supply and extortionate charges. A further development of municipal trading arises from the utilisation of the waste products of town life. Sewage is converted into manure; the establishment of sewage-farms leads to a trade in grass, to municipal market-gardens, or to municipal dairy-farms; street refuse, when burnt, is made into paving-blocks, and so on. Another branch of trading is the supply of water fittings or electric fittings ancillary to the municipal water or electricty supply; and it is curious that this comparatively small matter should at this late hour of the day have incited private traders to a crusade against municipal trading, destined to be as successful as the great war of the Scottish shopkeepers against co-operative stores.

Much debate has raged around the question whether municipalities should make a profit out of their undertakings or not. The matter is

one of degree only. Co-operative experience shows us that it is not possible to sell at cost price exactly; something extra must be charged and returned afterwards to the consumer. This is generally the practice of municipalities. The natural tendency will be to work services as near to their cost as possible; yet the various municipal services should be regarded not as separate undertakings, but as different departments of the business of running a municipality. From this point of view it will often be expedient to make a profit on one branch in order that the business may be extended in another direction—a very ordinary commercial principle. The net profit on reproductive municipal undertakings in England and Wales is £3,613,000 on a total capital expediture of £88,152,000; and in addition the price of gas, water, tramway journeys, etc., has been in most cases much reduced since the private companies were bought out. This surplus is usually applied in the reduction of rates, thereby indirectly providing a fund for future municipalisation. How far profits should be applied to lowering the price of the profitable commodity, or to the reduction of the general rate, or to the carrying out of some other object of common advantage, will entirely depend upon local circumstances, no general principle can be laid down. Every householder can use as much water as he pleases, and he pays not according to what he uses, but according to his ability; gas consumers, on the other hand, pay for what they use; and this diversity of treatment can be justified on the ground that the public health requires that every inducement should be given for the abundant use of water. Similarly, the necessities of a large town might very well demand that tramways should be free as the roads are. It may even be advantageous for a town to undertake a work which is a charge on the rates, on the ground that it is necessary to the welfare of the city; and for this reason Bristol is building docks and Manchester has made large investments in its ship canal. One thing must be guarded against: that the provision of some municipal service is not indirectly converted into a rate in aid of wages and transferred into the pockets of the landlords or employers. This has happened when tramways have been cheapened or extended, and rents have risen in consequence; and if the municipal houses were let, as it is often suggested, below the market rate, employers would be induced either to reduce or not to raise wages. Here, as in many other ways, we see that the intervention of the community in private enterprise must inevitably lead to further intervention.

Many towns have carried municipalisation almost to the extreme

limit which public opinion at present approves. In Glasgow, for example, all the ordinary services are municipalised, except the cemeteries. What industries will be next seized upon? The recent high price of coal has been a matter of gravity to those towns which run their own gasworks. In Manchester and Glasgow there are 500,000 tons of coal consumed annually in the gasworks of each town. Therefore the Gas Committee of the Manchester Town Council is considering a proposal to buy a coal mine of its own, and the Glasgow Town Council has only by a narrow majority rejected a similar suggestion. This is an obvious outlet for municipal activity, and we shall certainly hear more of it. The extension of municipal housing, with the ultimate conversion of the building trades into a municipal department, has already been mentioned. Next in order come, probably, the drink traffic, and the supply of bread, milk, and coals. Municipalisation of the drink trade will probably be undertaken partly for moral reasons, as with the Swiss alcohol monopoly, partly in order to eradicate from public life a pernicious political influence. Milk is proving such a dangerous medium for the spread of disease, and the difficulties of supervising the sanitary conditions of farms situated in other governing districts are so great, that these hygienic reasons will soon force municipalities, for the sake of their infant population, to provide their own milk supply. The baking trade is beset with combinations at every stage of the industry; and whatever else may be left to individual enterprise, the supply of the necessaries of life must not be exposed to the chances of industrial development. The same is largely true of the coal trade, which is above all others subject to vicissitudes of price. When the poor, who must buy their coal in small quantities, have to pay at the rate of forty shillings and upwards per ton, it is time for some public authority to step in. Some scattered cases of municipalisation in these industries can even now be adduced to show the ease with which municipalisation can be achieved. Birmingham has a municipal canteen at the navvies' village on its aqueduct works, which is very successful. The mining village of Hill of Beath in Fifeshire has had a municipal public-house for four years, and the experiment is being repeated with good results at Grayshott in Hants and elsewhere. Birmingham draws £4,500 per annum from the sale of milk at the dairy-farm in connection with its sewage-works. The Vooruit and other large co-operative bakeries show how well suited that industry is for centralised management, while Grenoble has achieved the more difficult task of running a municipal restaurant.

No British municipality has ever retraced one single step it has taken in the paths of municipalisation, and the natural monopolies which have been annexed have always been protected against a competitive service. In 1899 an attempt was made to break down this principle by the General Power Distributing Bill, which proposed to give a private company power to supply electricity in competition with municipalities over an area of two thousand square miles in the middle of England. The specious pretext was put forward that electricity could be distributed more cheaply in bulk from works at the pit's mouth, but nevertheless the company refused to supply Nottingham with current at the same price at which the city could produce it. So far this attack on municipal trading has been defeated. It is not necessary, however, that a municipality should always have a monopoly at first. It may be cheaper to compete than to buy out an over-capitalised concern, and this is the course which the Government is adopting with the National Telephone Company. Similarly with extensions of municipal enterprise: the first step in some cases may be to start municipal undertakings in competition with the private concerns, with a view of winning support for the project by the example of an efficient service.

One important result of municipal trading which is generally overlooked may be here pointed out—the increase in public honesty. In America individualism and private enterprise are rampant, and *The Economist* can say (14th July, 1900) "municipal corruption has attained to its full height in America." On the other hand, Mr. Harrison, the ex-Chairman of the Edinburgh Chamber of Commerce, confesses, "I desire to bear strong and emphatic testimony to the high level of work and high level of character which the town councils of this country have shown since their reform sixty years ago. There are always too many scandals in private trading, the history of joint-stock enterprise tells not a few stories of incompetence and dishonesty, but I do not know of any very flagrant case in which a town council has been proved dishonest to its trust."

Turning to the work of the central government, it must first of all be pointed out that all taxation, like all municipal rating, is so much nationalisation. A portion of the income of private individuals is appropriated and applied to the objects of national policy; in this way it is returned in another form to the taxpayers. For the purposes of public defence and other functions with which it is entrusted, the Government requires to have a large amount of supplies and a large amount of work

done, and these services it can obtain either through its own workmen or from private contractors. In so far as it adopts the former course, it, like a municipality in a similar case, carries one step further that elimination of subordinate agents in production which is one of the characteristic features of modern industry. The productive work of the Government as manufacturer is large and varied. The Dockyard Bill for wages is well over two millions yearly, and for material over a million and a half. The Royal Ordnance Factories have an output exceeding three millions, and the Army Clothing Factory of nearly two hundred and eighty thousand pounds. Government workmen execute new works and repairs to the value of some £700,000, and in the Navy victualling yards the "State" grinds flour, oatmeal, coffee, pepper, and mustard, salts beef and suet, and makes chocolate, scantling, casks, and hair-beds. On the other hand, contractors' bills are very heavy:—provisions, £2,400,000; forage, £520,000; clothing, £1,100,000; furniture, £74,000; coals for Navy, £864,000; fuel, light, and household articles, £560,000; shipbuilding, £3,500,000; armaments, £2,000,000; new works and repairs, £1,550,000; telegraph materials, £200,000; postage stamps, £186,000; conveyance of mails, etc., £3,150,000; cloth, etc., £640,000.

Not only is there plenty of scope for an extension of the Government manufacturing departments, but it closely concerns the safety of the country that that extension should take place. The great Engineering Dispute seriously delayed the shipbuilding programme; the Welsh Coal Strike caused the postponement of the naval manœuvres. Said the *Iron and Steel Trades Journal,* under the heading, "A Government Colliery Wanted": "Having a navy and national establishments which have cost a thousand millions, it is an anomaly that some poverty-stricken colliery companies and the 'poor colliers' should, by stopping the supply of fuel, be able, whenever they please, to place this country at the mercy of its enemies. We write 'poverty-stricken colliery companies,' well knowing that many very wealthy firms and some rich companies are engaged in the coal trade, but the chain is not stronger than its weakest link, and it is there in commerce as in mechanics the danger lies. The abandonment of the autumn manœuvres is dictated by common prudence. Will the First Lord of the Admiralty go further and say that prudence demands the establishment of Government collieries, which being manned above and below ground by Her Majesty's servants, will not be amenable to strikes, and will therefore always be raising coal for our ships, dockyards, and Government factories?"

Strikes, after all, are of infrequent occurrence, and a more serious statement was made by Mr. Goschen in his "Statement Explanatory of the Navy Estimates, 1900-1": "The abnormal activity in shipbuilding and engineering, which was described in the 'Statement' of last year, has continued during 1899-1900, and has seriously affected progress and expenditure on ships, machinery and armour. Delays in delivery of material, differences in securing adequate numbers of workmen, and other circumstances, have caused the aggregate earnings on contract work to fall short of the estimated amount by about £1,400,000, though the estimate was carefully calculated on the basis of actual earnings in past years on ships of similar character, and on very close investigations of the possible output of armour." When the nation's work cannot be done because trade is so prosperous, because manufacturers are so busy with private orders and with war-ships for foreign powers, then surely "prudence demands" that more Government factories shall be built. "It becomes a matter for serious consideration whether there should not be created an establishment for the manufacture of armour-plates solely for the dockyards, thereby relieving the makers of armour from the pressure which places private shipbuilders at a great disadvantage on Government contracts."

Professor Ashley has made a valuable suggestion as to one method by which the way may be prepared for collectivisation of industry. "I see nothing for it," he says, "but that in countries where the monopolising movement is well under way, the Governments should assume the duty of in some way controlling prices. The principle of public determination of maximum rates and maximum dividends has already been recognised in various countries in various directions; and it will doubtless have to be carried a good deal further. But before this can be done with any chance of tolerable success, any country which thinks of attempting it must provide itself with a fairly efficient administrative service." We already have railway rates and fares controlled to some extent by the Railway Commission; gas dividends have a maximum limit; and charges for electricity are subject to review by the Board of Trade. The Chambers of Commerce have repeatedly demanded that no mail subsidies should be granted to shipping companies which charge preferential rates against British traders, and this is a request which might very well be conceded. At present the home and colonial Governments pay about a million a year to enable the firms which own our mercantile marine to give a bounty to foreign manufacturers.

The fixing of rates and charges by a public department is only a temporary expedient, which, in the case of British railways, has conspicuously failed to secure justice. To quote a railway expert, Mr. Acworth: "For every shilling cut by an expeditious tribunal off a rate, it is easy for the railway companies, if they are agreed to act in harmony with each other, to withdraw two shillings' worth of facilities; and the traders may make up their minds that this is what must inevitably happen if the railway companies are confronted with lower rates simultaneously with a rapid rise of working expenses. Assume that your tribunal can fix a reasonable rate, what is the use of it unless it can schedule to its judgment a minute specification of the quality of service to be given in return for the rate? . . . The railways can bring down troops of expert witnesses. How can the tribunal refuse to hear them, when every student of railway economics knows that the reasonableness of each particular rate depends not merely on its own individual circumstances, but on a comparison with all the other rates and a consideration of the company's entire business? But for a farmer or shopkeeper, with the assistance, possibly, of the local attorney, to undertake to fight trained railway experts with a lifetime's experience and with every fact and figure at their fingers' end, is only to court defeat." The only remedy in such a case is national ownership, and the monopoly of transport will probably be the first great monopoly to be taken over by the British Government, which in this instance will follow well behind many continental and colonial governments. No better proof can be found of the way in which public opinion is maturing on this subject than a resolution passed at the annual meeting of the British Iron Trade Association on 13th June, 1900, asking for the appointment of a Royal Commission to take into consideration whether it would not be for the advantage of the trade and commerce of the country, and ultimately for the benefit of the State in its financial relations, that the railways should become national property, especially in view of the threatened increase of industrial competition from Germany, the United States of America, and other countries in which railway transport is run on different lines and carried on under different conditions. The President, Sir John J. Jenkins, M. P., estimated that 10 per cent of the gross annual return might be saved by the State through economies of management. Coal is as much of a necessity to commerce as railways, and, as Sir George Elliot has shown, is admirably adapted to central management. We may therefore expect that

nationalisation of the railways and mines will precede the collectivisation of the other industries.

Much has already been said about the dishonesty and recklessness which disgrace much of modern commerce and corrupt the national life. It bodes no good to the community that the advance towards the monopolisation of industry is accompanied by the wiles of the company-promoter. The purification of commercial life is of the greatest importance. Everything which raises the moral tone will facilitate reform by increasing the national impatience with industrial exploitation and tyranny. Good morals in their turn will produce good economics, and the destruction of dishonest forms of gain will make competition still more unprofitable.

In another way the State can do much to hasten industrial development. The State has had to step in and remedy the breakdown of apprenticeship by providing a system of technical instruction; it must go farther and substitute a system of scientific research for reliance on sporadic invention as a means of improving industry. At present the adoption of a new process as an improvement in machinery is—except in those large firms which maintain a scientific staff—left entirely to the hazard of the casual inventor succeeding, before he is starved out, in getting some capitalist to exploit him. And when an invention is taken up it is not made common to a whole industry, but is strictly preserved like game for private profit. A new industrial process is as much a fit subject for governmental study as a new gunpowder, and the State ought systematically to undertake the improvement of industry, prosecuting invention in its own laboratories and workshops—its manufacturing departments—especially when extended as proposed, affording ample means for experiment. An indirect but important consequence would be the elimination of the tendency to sterilisation of initiative and the inventive faculties—if it exists at all—which is alleged to be inherent in State management of industry.

Foreign trade is supposed always to be the rock on which a collectivised industry would break to pieces, but acquaintance with the working of combinations casts some doubt on this confident prediction. The German export trade in steel rails could not exist except through the co-operation of the "pool" formed by the chief producers of coal, pig-iron, steel rails, and the owners of blast-furnaces. A subsidy is levied on the members to form a fund out of which exporters are reimbursed for the difference between the selling price obtained and the

cost of production as fixed by the "pool." The manufacture of an increased quantity of steel, which this practice makes possible, reduces the general cost of production and enhances the profits from home sales. The great Coats monopoly again has no difficulty in deriving the greater part of its profits from its foreign trade. Mr. E. J. Smith, writing of his "alliances," says: "Combinations should trade abroad as combinations, not as individual firms. In each large town where single traders keep their showrooms, warehouses, and agents, heaping up expenses which either lessen profit or prevent sales, there should be one showroom, one warehouse, one general agent, lessening expenses, and providing an exhibition of articles much more imposing and attractive than any single firm can support." From these and many other facts it would appear that a Government department would not be without its advantages in conducting foreign trade.

SOCIAL CONDITIONS

ROBERT SOMERS

Robert Somers was born in Scotland September 14, 1822. He was early a well known lecturer on social and political questions. He became editor of the Edinburgh weekly *Scottish Herald* about 1844, then assistant editor to Hugh Miller of the *Witness*, and in 1847 took a place on the staff of the *North British Daily Mail*. From 1849 to 1859 he was editor of the *Mail*, and for the next eleven years of the *Morning Journal*. He traveled in the Southern States in 1870-1, and his work gives a fair view of the conditions there after the war. He died July 7, 1891.

THE SOUTH AFTER THE WAR

The Land Question in Virginia

[Richmond, Va., *Oct.* 26 to *Nov.* 23.]

The land question is the absorbing question in Virginia. How to get the estates formerly productive again brought into cultivation—how to attract settlers of a superior class from England and Scotland, who would take their place in Virginian society as landowners and give a fresh impulse to the work of improvement going on—how to fertilise the soil and increase and improve the farm stock—how to turn the woods, the mines, the beds of marl, the streams and waterfalls, the fruits and game, and all the abundance of nature to productive account, and so fill with new blood the wasted frame of the old Commonwealth, occupies the minds of all classes with an intensity of interest to which no other public concern can be compared. The first question asked of

a stranger is whether he has come to look at land. I was not three minutes in Richmond till a pushing Irishman offered to sell me a very fine milch cow and calf on the spot, or tell me where I could get a nice bit of land on very economical terms. But the stranger who is landward-bound is not left to such chance means of information. There are dozens of respectable estate agents, every one of whom has lists of farms and estate for sale which he advertises in the newspapers, and offers in fee-simple at a rate per acre that in England or Scotland, or even Ireland, would be deemed but a moderate annual rent, and payment of which he is willing to take in cash just enough to pay the expenses of suit, with the balance in instalments spread over three or four years. Every one of them states in private that he has even more lands on his list for sale than he advertises. Nor is this all. The State of Virginia has appointed a Board of Emigration, composed of gentlemen of the highest standing and reputation, with General Richardson, the Adjutant-General of the State, as secretary, whose sole object is to guide and assist, by every kindly office, persons from abroad wishing to invest a little capital and settle on the soil of Virginia. I might fill pages with a description of farms and plantations, and lots, large and small, of land that are thus in the market. But I shall only mention a few particulars from a list presented to me by General Richardson. To show the great variety of choice, as regards situation for example, some of these farms and estates are in the immediate neighbourhood of Richmond, some are in Roxbridge county, some in Orange county, others in Culpeper county, Chesterfield county, King William county, Louisa county, James City county, New Kent county, and so on. One is a tobacco plantation in Fluvanna, one of the most famous tobacco counties in Virginia. In the county of Orange there is an estate of 6,000 acres of improved land, with several dwelling-houses on it, the purchaser of which could make a large home-farm for himself, and have besides half a dozen or even a dozen farm tenants. The lands are "very fertile, and suited to grass." The purchase-money of this estate would be taken in instalments, spread over ten years if necessary. There are also many small farms, and lots of 20 to 50 acres. The highest price asked for any of these lands, which are improved, is 4*l.* per acre. One estate of 800 acres, "land good, with abundance of greensand marl only four feet below the surface," could be bought for fifteen dollars an acre. Among the number there are "2,000 acres of undeveloped coal lands." Land rights are carefully registered and guarded

in Virginia, and there is seldom any difficulty in tracing a clear title back through a long period of years.

To understand the avalanche of land bargains at present in Virginia, one has to remember that before the war the soil was owned chiefly by slaveholders, who had large estates which they never fully cultivated, but on which they shifted their crops about from one place to another, and who, finding themselves with plenty of money and little trouble under this system, allowed their overseers and the slave-dealers to settle all the hard matters between them. At the close of the war, when the slaves became free, it is easy to perceive that with no means left to cultivate such large tracts of land under the new conditions, it became a necessity, as well as the best thing the owners could do, to sell large portions of their estates, and to retain just as much as they had capital and labour to cultivate; and this they have done and are doing to some extent. In many other cases, proprietors, not rich save in land before the war, have since become embarrassed, and, falling into debt and arrears of taxes, have had decrees passed against them in the courts, under which sales are ordered to proceed. There have been instances also of gentlemen "slain in battle," or driven from the country, or flying from it in despair, and of every form of vicissitude and ruin that follows in the train of war and social revolution. The consequence is that a large proportion of the landed property of a great and long settled State is literally going a-begging for people to come and take it. The like has seldom been seen before. The deluge of encumbered estates in Ireland was nothing compared to it, for the land in Ireland, when brought to sale under a Parliamentary title, readily commanded purchasers at good prices. Yet there are no agrarian murders in Virginia. Nor is it a new and undeveloped country, where every element of civilization has to be introduced, but an old land of renown, where law and order prevail and every social comfort may be enjoyed. There is hardly any part of Virginia where a settler on the soil would not only find towns and markets, and roads and railways, but have as his neighbours gentlemen who are no mean agriculturists, who are versed in all the science of husbandry, many of them breeders of the rarest and finest stock, and deeply imbued with the spirit of agricultural progress and improvement.

The Race Question in South Carolina

Charleston—"old Charleston," fondly so called by its citizens—that

has braved "the battle and the breeze," if not a thousand, a good hundred years—the centre of Carolinian trade and commerce, the centre always of strong political emotion, and the centre also where the negro element was densest and negro slavery was intrenched as in a stronghold alike by fear and interest—is getting slowly, but surely, on its legs again from the downfall inflicted by the war. Never had a completer ruin fallen upon any city than fell upon Charleston in the years from 1860 to 1865. Her planters who, with noble country seats on the banks of pleasant streams, amid groves of live oaks affording deep shade from the summer sun, could afford to have their winter residences here in town, were reduced, as by the grinding of a nether millstone, from affluence to poverty—her merchants were scattered to the four winds of heaven—her shopkeepers closed their doors, or contrived to support a precarious existence on contraband of war—her young men went to die on the battlefield or in the military prisons of the North—her women and children, who could, fled to the country. The Federal Government, mindful of Fort Sumter and the first indignity to the Union flag, kept Charleston under close blockade, and added to its miseries by occasional bombardments. When this process in five years had reached the last stage of exhaustion, and the military surrender gave practical effect to emancipation, the negroes in the country parts, following up the child-like instinct of former days that Charleston was the El Dorado of the world, flocked into the ruined town, and made its aspect of misery and desolation more complete. The streets were empty of all but themselves; the houses had not only lost all their bright paint without, but were mostly tenantless within; many fine mansions, long deserted, were fast mouldering into decay and ruin; and the demand for labour and the supply of provisions were at the lowest point. Seldom, with a deeper ruin of the old, has there been a more hopeless chaos out of which to construct a new order of things than Charleston presented in those days. Yet the process of amelioration has year by year been going steadily forward. Many of the old merchants of the city, and many active agents of exchange, both new and old, have come to put the wheels of trade once more in motion. Some of the old planters have also survived, and are seen, though in diminished numbers and with saddened countenances, yet with the steady fire of Anglo-Saxon courage in their eyes, attending to affairs like men determined to conquer fortune even in the depths of ruin and on the brink of the grave; while others, not so much to be respected, unwilling to work and ashamed to

beg, seek to maintain some remnant of the ancient dignity no one knows how. The quays and wharves are busy; new ones, to meet new branches of trade, have been built with files of counting-rooms to suit; the cotton presses are again at work; lorries laden with the staple products of the interior pour the livelong day along the streets towards the river; revival is extending from the business parts of the town to the quiet quarters of private residence; and the hotels, always of the first consideration in America, are already, with their stately colonnades of white pillars, their freshly painted fronts, and their troops of polished waiters of various hues of ebony, magnificent in Charleston. I went down one evening to the Battery, an esplanade at the seaward end of the peninsula, formed by the Cooper and Ashley rivers, on which Charleston is built—not of great compass, seeing that the embouchure of the two rivers here draws the land to a narrow point, but beautiful and refreshing, looking out on the spacious bay direct to Fort Sumter and the far Atlantic, and calling up associations of the Spanish Main and the West Indies, the distant British Islands, and of naval and historic glory, at the crowding thoughts of which the heart of every English-speaking man leaps to his mouth. Though Charleston, like other cities, has its West End—as I have seen from the tower of the Orphan Asylum, a noble institution which the war has left in full vigour—where goodly houses along stretching avenues of trees, and ample garden grounds, afford a happy and elegant retreat to prosperous men of business, yet there is reason enough why the Battery should be a point of peculiar eminence and fashion in Charleston. The residences around the esplanade—palaces in their way—after long neglect, are undergoing rapid renovation. I am told that, apart from the "nabobs" who live in these charming marine villas, the Battery in ante-war times was the resort every evening of a long array of carriages, in which fair ladies reclined, and happy gentlemen cooled themselves after the heat and toil of the day. The only equipage I saw was the handsome buggy of a dry goods man from the North, who is rather liked for the spirit he displays. But the ladies of Charleston meantime take a constitutional walk on the Battery with their babies and nurses, and the gentlemen say the carriages will come again in due time.

Such is the hopeful uprising of commercial progress in Charleston just now. But the old town has much to recover. In the winter of 1862 a calamity more destructive and terrible than all the Federal bombardments befell the devoted city. A fire broke in some negro shanty

on the Cooper river, and favoured by the wind, spread and swept down all before it in a curious zigzag but generally straight line through the centre of the town, till stopped by the Ashley river on the other side. This appalling conflagration, the desolation and misery caused and the hospitality evoked by which, amidst all the troubles of the war, cannot be described, still leaves its mark, like the course of a caterpillar that has eaten its way over a cotton leaf, upon the city of Charleston. Fires, once sprung, must propagate here with fearful rapidity. A large proportion of the side streets of Charleston are built of wood. The houses are simply frame erections. They are all dry as tinder, and airy as they can be made. An accidental spark or flame which in our British towns would be instantly smothered by the damp atmosphere, the stone walls, the dense fogs, and the absence of sun and ventilation, is here fraught sometimes with alarming consequences. Not the slightest suspicion of incendiarism rested upon the great Charleston fire of 1862. The negro is not given to the folly of setting his house on fire to roast an egg for somebody else to eat; and such is the power of discipline and habit over him, that he continues, save on election nights or other periods of great excitement, to turn into bed at the early hour in the evening prescribed to him by a sort of curfew law in the days of slavery. The question asked when one surveys the vast ruin caused by this fire is, What became of the insurance companies? The insurance companies of the South? The war soon rendered their position untenable. The number of persons caring to insure rapidly diminished, and as the destruction of fire and sword spread wider and wider, the companies went down by the board, till the whole insurance capital of the Southern States, and all the interests centred around it, shrivelled up like a scroll and disappeared. One must go to Charleston in order to hear all the ruin of the war summed up in good round emphatic English. Any old merchant citizen will reckon on his fingers what the war lost of property, capital, and substance of every kind to the South. First, the property in negroes, which, whether property in right reason and natural equity or not, was introduced under the sway of England, was recognised by the Constitution of the Republic, was protected by the laws of the United States, and was to all material intents and purposes as essentially property in the South as anything elsewhere which makes profit and can be bought and sold;—this property was abolished, and was four hundred millions sterling. The whole banking capital of the South, which cannot be estimated at less than two hundred millions more, was swamped

in the extinction of all profitable banking business, and, finally, in a residuary flood of worthless Confederate money. The whole insurance capital of the South—probably a hundred millions more—also perished. The well organized cotton, sugar, and tobacco plantations, mills, factories, coal and iron mines, and commercial and industrial establishments, built up by private capital, the value of which in millions of pounds sterling cannot be computed—all sank and were engulfed in the same wave. Every form of mortgage claim, with the exception of two or three proud State stocks, shared for the time being the fate of the principal, and only now crops up amidst the subsiding deluge like the stumps of a submerged forest. And so on the account goes as long as the fingers hold out, till the demonstration made is that the South by the war was peeled to the bone, and left not only without a cent in its pocket, but without anything by which a cent could be made, save the rude but productive land and the bright sun, powerful indeed as natural germs of wealth and prosperity, but needing, to give them vitality, more capital and labour, more invention and ingenuity, more of everything which it seemed most difficult to supply. Terrible though the picture of ruin and impoverishment be, as thus drawn here in Charleston, I suspect it is in the main true of the whole South, and the marvel must be that affairs should already be so lively, so hopeful and elastic, as they everywhere appear. It was to be expected that the young men would enter upon business with fresh life and energy; but more remarkable than they are the men of advanced life who, still on the top of the wave, are guiding and controlling by their experience the new order of things.

Charleston, like Boston—for a good comparison there is nothing like the antipodes—has an English look about it. The old city has not fallen so mathematically into the parallelogram formation as the cities of the United States in general. The inhabitants still cast many a fond look towards the old country, and contrast the present misrule with the time when the laws of England were the laws of South Carolina. Such is the deep sense of change and revolution produced by the downfall of State Rights and the inroad of Federal power and innovation, that they profess not to know what the laws of South Carolina now are, or whether she has any laws at all. Ask what the system of rule is, and the reply will uniformly be that it is "nigger rule," which is in one sense true. The negroes are more numerous than the whites in South Carolina. Being all citizens of the United States, they have all the right of

voting, while many of the whites are not naturalized; and the War Radicals who came in to take the lead in political affairs, and to hold offices for which the prominent men of the State were disqualified by the test oath, have succeeded in controlling the negro vote, and casting it almost *en masse* in their favour at the polls. There not being "carpet-baggers" or "scallowags" enough in the State to fill all the seats in the Legislature, the negroes have largely returned men of their own race to watch over "laws and learning," "ships, colonies, and commerce," at the Capitol. The House of Representatives consists of 80 coloured men and 44 whites, and the Senate of 11 coloured men and 20 whites—there being one seat vacant just now. The white people of South Carolina are thus practically disfranchised, and a proletariat Parliament has been constituted, the like of which could not be produced under the widest suffrage in any part of the world save in some of these Southern States. The outcry of misgovernment, extravagant expenditure, jobbery, and corruption is both loud and general. The negroes are declared to be the dupes of designing men, comparative strangers to the State, whose object is simply to fill their pockets out of the public spoil. Political charges are not minced in South Carolina. There is room, indeed, to hope for a good deal of exaggeration. The exclusion of the superior part of the population from all influence in public affairs must of itself tend to magnify the enormity of everything enormous, and to distort everything not quite square that is done. The members and dependants of the State Administration are said, after having depreciated the South Carolina bonds to 40 and 35 cents, and bought in largely at such prices, to have then offered gold interest at New York, which at once advanced the price to 95 cents, and enabled them to pocket millions. Possible and condemnatory enough, but it was a good thing in itself to restore the financial credit of the State; and in North Carolina, for example, the business men and the proprietors have since the war urged upon the Legislature to place the public credit of the State on the best footing, and will not desist till they succeed, under the conviction that honesty to the public creditor is the best policy, and the corner-stone of all progress and improvement. State Commissions are said to be issued on roads, lands, and other departments, the members of which do little but job and make profit to themselves and their friends. The State Government buys lands on which to settle and give homes to negroes. This is commissioned, and land is said to undergo sale and resale before it becomes the property of the State. It is not believed that the negroes

will in any considerable number make homes on these properties, and the only advantage I have incidentally discovered from such settlements is in one instance where the negroes, not having crops enough of their own to occupy their labour, formed a reserve force from which a neighbouring planter has drawn extra hands to gather in his cotton. Railway contracts and railway bonds, in which the State has its finger, are also suspected of offering opportunities not exactly consistent with the public good. The phosphate deposits in the bay and rivers have been leased at a royalty of a dollar per ton to a single company, not, I am to believe, without heavy sums distributed in the House of Representatives; but the principle of this transaction is discussed freely by all parties, and it is thought by some that the law of the United States will not sanction a commercial monopoly of what is public estate. A State census was taken last year, which is thought to have been a superfluous labour, seeing that the decennial census ordered by Congress fell to be taken this year, and the Governor is supposed to have sought in this way to give employment to partisans, and to securé votes. Everything thus moves in an atmosphere of political suspicion. One of the most favourable signs, indeed, is the keenness with which the acts of the State Government and Legislature are scrutinized, and the activity with which the native white population endeavour to recover influence and authority both in the State and in Congress. Prior to the recent elections, they organised a Reform Union on the basis of the political and civil equality of the negroes, turned out in large numbers to the ballot boxes, protected the negroes who were voting on their side, and in Charleston succeeded. But throughout the State the movement so far has failed to divide the negro vote with the Radical party, who remain in a large majority. The principles of the Reform Union seem to be consistently maintained in practice. Many of the white electors in the city voted for Delarge, a negro tailor, as representative of their district in Congress, because they believed him to be more trustworthy than his white opponents.

I allude at this length to political affairs in South Carolina, because it is very obvious that a system of government resting almost wholly on the votes of the negroes, is not a desirable state of affairs as regards either the State itself or the general interests of the Union. It destroys confidence in the integrity and stability of the Administration, prevents the investment of money, and renders impossible that hearty co-operation of the public authorities with the substantial people of the State which is so essential to the interests of all classes of the community.

[CHARLESTON, S. C.—*Nov.* 10 to *Nov.* 14.]

Apart from the passing excitement of the elections just over, and the disappointment of the white population at the voting of the negroes *en masse* for the Republican or Radical party, the general tone of social life in Charleston is kindly and temperate, and all classes of society are working together with considerable harmony for mutual good. The negro is beset at present by two parties who claim to be his "best friends." The Republicans, who came in with the close of the war, appeal to him as his best if not only friends; and, looking at the political issues of the war, and the decree of emancipation, with its elaborate guarantees of reconstruction, the negroes could not but regard the Republican party politically as their friends. Nor can it be denied that the organs of the Federal Government have laboured to introduce institutions for the moral and social benefit of the negroes, and, as far as their limited means would allow, have befriended that large portion of the population. I have not found any one on the other side who is prepared to blame the negroes for voting almost universally as they did in the elections which raised General Grant to the Presidentship, or who appears to have expected that they would or should have been other than fast adherents of their emancipators. But the political agitators and hungry spoil-and-office hunters of the party are accused of appealing to the ignorance and passions of the negro population—of telling them that the white people of the State are eagerly seeking an opportunity of restoring slavery, which they have certainly no wish to do, and which they could not do even if they would; and now, after five years of this, it is considered hard that the negroes—when there are great public objects of economy, protection from jobbery and corruption, and a sound and healthy administration of the affairs of the State to promote, in which the blacks are as closely interested as others—should cast their votes in a body against the great majority of the white population, and terrorize such of their own colour as are disposed to act differently. This feeling breaks out violently just now in bar-rooms and at street corners, and is often expressed more quietly and reasonably, yet firmly, in private circles. Many seem ready to despair of the negro as a politician, while others talk of a "war of races" and other disorders sure to arise. The feeling is no doubt all the stronger since the evils of "carpet-bagging" and negro demagoguery are apparent to respectable men of both parties, and, while violently denounced on one side, are not denied, but sometimes admitted and deplored, on the other.

Though politics in South Carolina thus wear a somewhat sinister complexion, yet there is a healthy action and a sober practical opinion underneath the service that promise beneficial results. The issues left by the war are being rapidly closed; the *Reform Union,* which has figured prominently in the late elections as the organ of the native white people of the State, recognizes fully the civil and political equality of the negroes not only as an election platform, but as the fundamental law of the United States; this position is likely to be maintained, and may be expected soon to bring about in this, as in other Southern States, a better balance of parties. Meanwhile social bonds are being knit together, and many ameliorative influences are quietly at work. The ladies, who had a long apprenticeship of self-devotion during the war, are exerting themselves to give work, and to sell the work of poor needlewomen of both races. Nearly all the old charities of Charleston remain in operation, and schools and missions are doing much to improve the population.

By a law passed five years before the war a public school system was introduced into South Carolina, which became well developed in Charleston; and now the State has passed under the new free-school principle, embodied in the Constitutions of the Southern States under the Acts of Reconstruction. It is only by degrees that this system can get into general operation, and, indeed, it is doubtful whether the ground lost in education during the war has yet been recovered. The official statistics for 1860 give 20,716 pupils in 757 public schools, whereas they show for 1869 only 381 public schools and 16,418 pupils. The new law is now, however, being put into operation; the State has appropriated $50,000 to this object, and, aided by the Peabody Fund and other voluntary contributions, South Carolina may be expected soon to be tolerably well furnished with the means of education for the whole population. Charleston is probably more advanced in this respect than any other part of the State, and the education of negro children is already quite a prominent feature, one building devoted to the coloured people being capable of receiving 1,000 scholars.

REDFIELD PROCTOR

REDFIELD PROCTOR was born at Proctorsville, Vermont, in 1831. He became Governor of his State in 1878, Secretary of War in 1889, and United States Senator in 1891.

Before the Spanish-American War, he made a special investigation for his own sake of the conditions in Cuba. Considerable previous experience in the island fitted him admirably to be a competent judge, and the speech given below—a plain, conservative statement of affairs there—had the greatest influence in convincing the Senate of the necessity of interference for reasons of humanity.

CONDITIONS IN CUBA

Mr. President, more importance seems to be attached by others to my recent visit to Cuba than I have given it, and it has been suggested that I make a public statement of what I saw and how the situation impressed me. This I do on account of the public interest in all that concerns Cuba, and to correct any inaccuracies that have, not unnaturally, appeared in some of the reported interviews with me.

My trip was entirely unofficial, and of my own motion, not suggested by anyone. The only mention I made of it to the President was to say to him that I contemplated such a trip and to ask him if there was any objection to it; to which he replied that he could see none. No one but myself, therefore, is responsible for anything in this statement. Judge Day gave me a brief note of introduction to General Lee, and I had letters of introduction from business friends at the North to bankers and other business men at Habana, and they in turn gave me letters to their correspondents in other cities. These letters to business men were very useful, as one of the principal purposes of my visit was to ascertain the views of practical men of affairs upon the situation.

Of General Lee I need say little. His valuable services to his country in his trying position are too well known to all his countrymen to require mention. Besides his ability, high character, and courage, he possesses the important requisites of unfailing tact and courtesy, and,

withal, his military education and training and his soldierly qualities are invaluable adjuncts in the equipment of our representative in a country so completely under military rule as is Cuba. General Lee kindly invited us to sit at his table at the hotel during our stay in Habana, and this opportunity for frequent informal talks with him was of great help to me.

In addition to the information he voluntarily gave me, it furnished a convenient opportunity to ask him the many questions that suggested themselves in explanation of things seen and heard on our trips through the country. I also met and spent considerable time with Consul Brice at Matanzas, and with Captain Barker, a stanch ex-Confederate soldier, the consul at Sagua la Grande, a friend of the Senator from Mississippi [Mr. Walthall]. None of our representatives whom I met in Cuba are of my political faith, but there is a broader faith, not bounded by party lines. They are all three true Americans, and have done excellent service.

The Maine

It has been stated that I said there was no doubt the Maine was blown up from the outside. This is a mistake. I may have said that such was the general impression among Americans in Habana. In fact, I have no opinion about it myself, and carefully avoided forming one. I gave no attention to these outside surmises. I met the members of the court on their boat, but would as soon approach our Supreme Court in regard to a pending case as that board. They are as competent and trustworthy within the lines of their duty as any court in the land, and their report, when made, will carry conviction to all the people that the exact truth has been stated just as far as it is possible to ascertain it. And until then surmise and conjecture are idle and unprofitable. Let us calmly wait for the report.

Sections Visited

There are six provinces in Cuba, each, with the exception of Matanzas, extending the whole width of the island, and having about an equal sea front on the north and south borders. Matanzas touches the Caribbean Sea only at its southwest corner, being separated from it elsewhere by a narrow peninsula of Santa Clara Province. The provinces are named, beginning at the west, Pinar del Rio, Habana, Matanzas, Santa Clara, Puerto Principe, and Santiago de Cuba. My observations were confined to the four western provinces, which constitute about one-half of the island. The two eastern ones are practically in the hands of the insurgents, except the few fortified towns. These two large provinces are spoken of to-day as "Cuba Libre."

Habana, the great city and capital of the island, is, in the eyes of the Spaniards and many Cubans, all Cuba, as much as Paris is France. But having visited it in more peaceful times and seen its sights, the tomb of Columbus, the forts—Cabana and Morro Castle, etc.—I did not care to repeat this, preferring trips in the country. Everything seems to go on much as usual in Habana. Quiet prevails, and except for the frequent squads of soldiers marching to guard and police duty and their abounding presence in all public places, one sees little signs of war.

Outside Habana all is changed. It is not peace nor is it war. It is desolation and distress, misery and starvation. Every town and village is surrounded by a "trocha" (trench), a sort of rifle pit, but constructed on a plan new to me, the dirt being thrown up on the inside and a barbed wire fence on the outerside of the trench. These trochas have at every corner and at frequent intervals along the sides what are there called forts, but which are really small blockhouses, many of them more like large sentry boxes, loopholed for musketry, and with a guard of from two to ten soldiers in each.

The purpose of these trochas is to keep the reconcentrados in as well as to keep the insurgents out. From all the surrounding country the people have been driven in to these fortified towns and held there to subsist as they can. They are virtually prison yards, and not unlike one in general appearance, except that the walls are not so high and strong; but they suffice, where every point is in range of a soldier's rifle, to keep in the poor reconcentrado women and children.

Every railroad station is within one of these trochas and has an armed guard. Every train has an armored freight car, loopholed for musketry and filled with soldiers, and with, as I observed usually, and was informed is always the case, a pilot engine a mile or so in advance. There are frequent blockhouses inclosed by a trocha and with a guard along the railroad track. With this exception there is no human life or habitation between these fortified towns and villages, and throughout the whole of the four western provinces, except to a very limited extent among the hills where the Spaniards have not been able to go and drive the people to the towns and burn their dwellings. I saw no house or hut in the 400 miles of railroad rides from Pinar del Rio Province in the west across the full width of Habana and Matanzas provinces, and to Sagua La Grande on the north shore, and to Cienfuegos on the south shore of Santa Clara, except within the Spanish trochas.

There are no domestic animals or crops on the rich fields and pas-

tures except such as are under guard in the immediate vicinity of the towns. In other words, the Spaniards hold in these four western provinces just what their army sits on. Every man, woman, and child, and every domestic animal, wherever their columns have reached, is under guard and within their so-called fortifications. To describe one place is to describe all. To repeat, it is neither peace nor war. It is concentration and desolation. This is the "pacified" condition of the four western provinces.

West of Habana is mainly the rich tobacco country; east, so far as I went, a sugar region. Nearly all the sugar mills are destroyed between Habana and Sagua. Two or three were standing in the vicinity of Sagua, and in part running, surrounded, as are the villages, by trochas, and "forts" or palisades of the royal palm, and fully guarded. Toward and near Cienfuegos there were more mills running, but all with the same protection. It is said that the owners of these mills near Cienfuegos have been able to obtain special favors of the Spanish Government in the way of a large force of soldiers, but that they also, as well as all the railroads, pay taxes to the Cubans for immunity. I had no means of verifying this. It is the common talk among those who have better means of knowledge.

The Reconcentrados—The Country People

All the country people in the four western provinces, about 400,000 in number, remaining outside the fortified towns when Weyler's order was made were driven into these towns, and these are the reconcentrados. They were the peasantry, many of them farmers, some landowners, others renting lands and owning more or less stock, others working on estates and cultivating small patches; and even a small patch in that fruitful clime will support a family.

It is but fair to say that the normal condition of these people was very different from what prevails in this country. Their standard of comfort and prosperity was not high measured by ours. But according to their standards and requirements their conditions of life were satisfactory.

They lived mostly in cabins made of palms or in wooden houses. Some of them had houses of stone, the blackened walls of which are all that remain to show the country was ever inhabited.

The first clause of Weyler's order reads as follows:

I Order and Command

First. All the inhabitants of the country or outside of the line of

fortifications of the towns shall, within the period of eight days, concentrate themselves in the towns occupied by the troops. Any individual who, after the expiration of this period, is found in the uninhabited parts will be considered a rebel and tried as such.

The other three sections forbid the transportation of provisions from one town to another without permission of the military authority, direct the owners of cattle to bring them into the towns, prescribe that the eight days shall be counted from the publication of the proclamation in the head town of the municipal district, and state that if news is furnished of the enemy which can be made use of, it will serve as a "recommendation."

Many, doubtless, did not learn of this order. Others failed to grasp its terrible meaning. Its execution was left largely to the guerrillas to drive in all that had not obeyed, and I was informed that in many cases the torch was applied to their homes with no notice, and the inmates fled with such clothing as they might have on, their stock and other belongings being appropriated by the guerrillas. When they reached the towns they were allowed to build huts of palm leaves in the suburbs and vacant places within the trochas, and left to live, if they could.

Their huts are about 10 by 15 feet in size, and for want of space are usually crowded together very closely. They have no floor but the ground, no furniture, and, after a year's wear, but little clothing except such stray substitutes as they can extemporize; and with large families, or more than one, in this little space, the commonest sanitary provisions are impossible. Conditions are unmentionable in this respect. Torn from their homes, with foul earth, foul air, foul water, and foul food or none, what wonder that one-half have died and that one-quarter of the living are so diseased that they cannot be saved? A form of dropsy is a common disorder resulting from these conditions. Little children are still walking about with arms and chest terribly emaciated, eyes swollen, and abdomen bloated to three times the natural size. The physicians say these cases are hopeless.

Deaths in the streets have not been uncommon. I was told by one of our consuls that they have been found dead about the markets in the morning, where they had crawled, hoping to get some stray bits of food from the early hucksters, and that there had been cases where they had dropped dead inside the market surrounded by food. These people were independent and self-supporting before Weyler's order. They are not beggars even now. There are plenty of professional beggars in

every town among the regular residents, but these country people, the reconcentrados, have not learned the art. Rarely is a hand held out to you for alms when going among their huts, but the sight of them makes an appeal stronger than words.

The Hospitals

Of these I need not speak. Others have described their conditions far better than I can. It is not within the narrow limits of my vocabulary to portray it. I went to Cuba with a strong conviction that the picture had been overdrawn; that a few cases of starvation and suffering had inspired and stimulated the press correspondents, and that they had given free play to a strong, natural, and highly cultivated imagination.

Before starting I received through the mail a leaflet published by the Christian Herald, with cuts of some of the sick and starving reconcentrados, and took it with me, thinking these must be rare specimens, got up to make the worst possible showing. I saw plenty as bad and worse; many that should not be photographed and shown.

I could not believe that out of a population of 1,600,000, 200,000 had died within these Spanish forts, practically prison walls, within a few months past from actual starvation and diseases caused by insufficient and improper food. My inquiries were entirely outside of sensational sources. They were made of our medical officers, of our consuls, of city alcaldes (mayors), of relief committees, of leading merchants and bankers, physicians, and lawyers. Several of my informants were Spanish born, but every time the answer was that the case had not been overstated. What I saw I cannot tell so that others can see it. It must be seen with one's own eyes to be realized.

The Los Pasos Hospital, in Habana, has been recently described by one of my colleagues, Senator Gallinger, and I cannot say that his picture was overdrawn, for even his fertile pen could not do that. But he visited it after Dr. Lesser, one of Miss Barton's very able and efficient assistants, had renovated it and put in cots. I saw it when 400 women and children were lying on the stone floors in an indescribable state of emaciation and disease, many with the scantiest covering of rags —and such rags!—sick children, as naked as they came into the world; and the conditions in the other cities are even worse.

Miss Barton and Her Work

Miss Barton needs no indorsement from me. I had known and esteemed her for many years, but had not half appreciated her capa-

bility and devotion to her work. I specially looked into her business methods, fearing that here would be the greatest danger of mistake, that there might be want of system and waste and extravagance, but found she could teach me on these points. I visited the warehouse where the supplies are received and distributed; saw the methods of checking; visited the hospitals established or organized and supplied by her; saw the food distributions in several cities and towns, and everything seems to me to be conducted in the best manner possible. The ample, fine warehouse in Habana, owned by a Cuban firm, is given, with a gang of laborers free of charge to unload and reship supplies.

The Children's Hospital in Havana, a very large, fine private residence, is hired at a cost of less than $100 per month, not a fifth of what it would command in this city. It is under the admirable management of Mrs. Dr. Lesser of New York, a German lady and trained nurse. I saw the rapid improvement of the first children taken there. All Miss Barton's assistants seem excellently fitted for their duties. In short, I saw nothing to criticise, but everything to commend. The American people may be assured that their bounty will reach the sufferers with the least possible cost and in the best manner in every respect. And if our people could see a small fraction of the need, they would pour more "freely from their liberal stores" than ever before for any cause.

When will the need for this help end? Not until peace comes and the reconcentrados can go back to the country, rebuild their homes, reclaim their tillage plots, which quickly run up to brush in that wonderful soil and clime, and until they can be free from danger of molestation in so doing. Until then the American people must in the main care for them. It is true that the alcaldes, other local authorities, and the relief committees are now trying to do something, and desire, I believe, to do the best they can. But the problem is beyond their means and capacity, and the work is one to which they are not accustomed.

General Blanco's order of November 13 last somewhat modifies the Weyler order, but it is of little or no practical benefit. Its application is limited to farms "properly defended," and the owners are obliged to build "centers of defense." Its execution is completely in the discretion of the local military authorities, and they know the terrible military efficiency of Weyler's order in stripping the country of all possible shelter, food, or source of information for an insurgent, and will be slow to surrender this advantage. In fact, though the order was issued four months ago, I saw no beneficent results from it worth mentioning.

I do not impugn General Blanco's motives, and believe him to be an amiable gentleman, and that he would be glad to relieve the condition of the reconcentrados if he could do so without loss of any military advantage; but he knows that all Cubans are insurgents at heart, and none now under military control will be allowed to go out from under it.

I wish I might speak of the country—of its surpassing richness. I have never seen one to compare with it. On this point I agree with Columbus, and believe everyone between his time and mine must be of the same opinion. It is indeed a land—

Where every prospect pleases
And only man is vile.

The Spaniard

I had little time to study the race question, and have read nothing on it, so can only give hasty impressions. It is said that there are nearly 200,000 Spaniards in Cuba out of a total population of 1,600,000. They live principally in the towns and cities. The small shopkeepers in the towns and their clerks are mostly Spaniards. Much of the larger business, too, and of the property in the cities, and in a less degree in the country, is in their hands. They have an eye to thrift, and as everything possible in the way of trade and legalized monopolies, in which the country abounds, is given to them by the Government, many of them acquire property. I did not learn that the Spanish residents of the island had contributed largely in blood or treasure to suppress the insurrection.

The Cuban

There are, or were before the war, about 1,000,000 Cubans on the island, 200,000 Spaniards (which means those born in Spain), and less than half a million of negroes and mixed bloods. The Cuban whites are of pure Spanish blood and, like the Spaniards, dark in complexion, but oftener light or blonde, so far as I noticed. The percentage of colored to white has been steadily diminishing for more than fifty years, and is not now over 25 per cent of the total. In fact, the number of colored people has been actually diminishing for nearly that time. The Cuban farmer and laborer is by nature peaceable, kindly, gay, hospitable, light-hearted, and improvident.

There is a proverb among the Cubans that "Spanish bulls cannot be bred in Cuba"—that is, that the Cubans, though they are of Spanish blood, are less excitable and of a quieter temperament. Many Cubans whom I met spoke in strong terms against the bull fights; that it was a brutal institution, introduced and mainly patronized by the Spaniards.

One thing that was new to me was to learn the superiority of the well-to-do Cuban over the Spaniard in the matter of education. Among those in good circumstances there can be no doubt that the Cuban is far superior in this respect. And the reason of it is easy to see. They have been educated in England, France, or this country, while the Spaniard has such education as his own country furnishes.

The Negro

The colored people seem to me by nature quite the equal mentally and physically of the race in this country. Certainly physically they are by far the larger and stronger race on the island. There is little or no race prejudice, and this has doubtless been greatly to their advantage. Eighty-five years ago there were one-half as many free negroes as slaves, and this proportion slowly increased until emancipation.

The Military Situation

It is said that there are about 60,000 Spanish soldiers now in Cuba fit for duty out of the over 200,000 that have been sent there. The rest have died, have been sent home sick, or are in hospitals, and some have been killed, notwithstanding the official reports. They are conscripts, many of them very young, and generally small men. One hundred and thirty pounds is a fair estimate of their average weight. They are quiet and obedient, and if well drilled and led, I believe would fight fairly well, but not at all equal to our men. Much more would depend on the leadership than with us. The officer must lead well and be one in whom they have confidence, and this applies to both sides alike. As I saw no drills or regular formation, I inquired about them of many persons, and was informed that they had never seen a drill. I saw perhaps 10,000 Spanish troops, but not a piece of artillery or a tent. They live in barracks in the towns, and are seldom out for more than the day, returning to town at night.

They have little or no equipment for supply trains or for a field campaign such as we have. Their cavalry horses are scrubby little native ponies, weighing not over 800 pounds, tough and hardy, but for the most part in wretched condition, reminding one of the mounts of Don Quixote and his squire. Some of the officers, however, have good horses, mostly American, I think. On both sides cavalry is considered the favorite and the dangerous fighting arm. The tactics of the Spanish, as described to me by eyewitnesses and participants in some of their battles, is for the infantry, when threatened by insurgent cavalry, to form a hollow square and fire away *ab libitum,* and without ceasing until time to march back to town.

It does not seem to have entered the minds of either side that a good infantry force can take care of itself and repulse anywhere an equal or greater number of cavalry, and there are everywhere positions where cavalry would be at a disadvantage.

Having called on Governor and Captain-General Blanco and received his courteous call in return, I could not with propriety seek communication with insurgents. I had plenty of safe offers of safe conduct to Gomez's camp, and was told that if I would write him, an answer would be returned safely within ten days at most.

I saw several who had visited the insurgent camps, and was sought out by an insurgent field officer, who gave me the best information received as to the insurgent force. His statements were moderate, and I was credibly informed that he was entirely reliable. He claimed that the Cubans had about 30,000 men now in the field, some in every province, but mostly in the two eastern provinces and eastern Santa Clara, and this statement was corroborated from other good sources. They have a force all the time in Habana Province itself, organized in four small brigades and operating in small bands. Ruiz was taken, tried, and shot within about a mile and a half of the railroad and about fifteen miles out of Habana, on the road to Matanzas, a road more traveled than any other, and which I went over four times.

Arranguren was killed about three miles the other side of the road and about the same distance, fifteen or twenty miles, from Habana. They were well armed, but very poorly supplied with ammunition. They are not allowed to carry many cartridges; sometimes not more than one or two. The infantry, especially, are poorly clad. Two small squads of prisoners which I saw, however, one of half a dozen in the streets of Habana, and one of three on the cars, wore better clothes than the average Spanish soldier.

Each of these prisoners, though surrounded by guards, was bound by the arm and wrists by cords, and they were all tied together by a cord running along the line, a specimen of the amenities of their warfare. About one-third of the Cuban army are colored, mostly in the infantry, as the cavalry furnished their own horses.

This field officer, an American from a Southern State, spoke in the highest terms of the conduct of these colored soldiers; that they were as good fighters and had more endurance than the whites; could keep up with the cavalry on a long march and come in fresh at night.

The Political Situation

The dividing lines between parties are the most straight and clear cut that have ever come to my knowledge. The division in our war was by no means so clearly defined. It is Cuban against Spaniard. It is practically the entire Cuban population on one side and the Spanish army and Spanish citizens on the other.

I do not count the autonomists in this division, as they are so far too inconsiderable in numbers to be worth mentioning. General Blanco filled the civil offices with men who had been autonomists and were still classed as such. But the march of events had satisfied most of them that the chance for autonomy came too late.

It falls as talk of compromise would have fallen the last year or two of our war. If it succeeds, it can only be by armed force, by the triumph of the Spanish army, and the success of Spanish arms would be easier by Weyler's policy and method, for in that the Spanish army and people believe.

There is no doubt that General Blanco is acting in entire good faith; that he desires to give the Cubans a fair measure of autonomy, as Campos did at the close of the ten-year war. He has, of course, a few personal followers, but the army and Spanish citizens do not want genuine autonomy, for that means government by the Cuban people. And it is not strange that the Cubans say it comes too late.

I have never had any communication, direct or indirect, with the Cuban Junta in this country or any of its members, nor did I have with any of the juntas which exist in every city and large town of Cuba. None of the calls I made were upon parties of whose sympathies I had the least knowledge, except that I knew some of them were classed as autonomists.

Most of my informants were business men, who had no sides and rarely expressed themselves. I had no means of guessing in advance what their answers would be, and was in most cases greatly surprised at their frankness.

I inquired in regard to autonomy of men of wealth and men as prominent in business as any in the cities of Habana, Matanzas, and Sagua, bankers, merchants, lawyers, and autonomist officials, some of them Spanish born but Cuban bred, one prominent Englishman, several of them known as autonomists, and several of them telling me they were still believers in autonomy if practicable, but without exception they replied that it was "too late" for that.

Some favored a United States protectorate, some annexation, some free Cuba; not one has been counted favoring the insurrection at first. They were business men and wanted peace, but said it was too late for peace under Spanish sovereignty. They characterized Weyler's order in far stronger terms than I can. I could not but conclude that you do not have to scratch an autonomist very deep to find a Cuban. There is soon to be an election, but every polling place must be inside a fortified town. Such elections ought to be safe for the "ins."

I have endeavored to state in not intemperate mood what I saw and heard, and to make no argument thereon, but leave everyone to draw his own conclusions. To me the strongest appeal is not the barbarity practiced by Weyler nor the loss of the Maine, if our worst fears should prove true, terrible as are both of these incidents, but the spectacle of a million and a half of people, the entire native population of Cuba, struggling for freedom and deliverance from the worst misgovernment of which I ever had knowledge. But whether our action ought to be influenced by any one or all these things, and, if so, how far, is another question.

I am not in favor of annexation; not because I would apprehend any particular trouble from it, but because it is not wise policy to take in any people of foreign tongue and training, and without any strong guiding American element. The fear that if free the people of Cuba would be revolutionary is not so well founded as has been supposed, and the conditions for good self-government are far more favorable. The large number of educated and patriotic men, the great sacrifices they have endured, the peaceable temperament of the people, whites and blacks, the wonderful prosperity that would surely come with peace and good home rule, the large influx of American and English immigration and money, would all be strong factors for stable institutions.

But it is not my purpose at this time, nor do I consider it my province, to suggest any plan. I merely speak of the symptoms as I saw them, but do not undertake to prescribe. Such remedial steps as may be required may safely be left to an American President and the American people.

F. H. SAWYER

F. H. Sawyer was British consul in Manila and a resident there for some fourteen years.

PROSPECTS IN THE PHILIPPINES

The commercial prospects of the islands are great, even if we do not instantly take for gospel the fairy tales we are told about Manila becoming the centre of the trade of the Pacific. There can be no doubt that if peace and an honest administration can be secured, capital will be attracted and considerable increase in the export of hemp, tobacco, and sugar will gradually take place as fresh land can be cleared and planted. As I have elsewhere said, the Philippines in energetic and skillful hands will soon yield up the store of gold which the poor Spaniards have been so mercilessly abused for leaving behind them. But the Philippines are not and never will be a country for the poor white man.

A white man cannot labour there without great danger to his health. He cannot compete with the native or Chinese mechanic, in fact he is not wanted there at all. For my part, I would never employ a white man there as a labourer or mechanic, if I could help it, more especially an Englishman or an American, for I know from experience what the result would be. As foreman or overseer a white man may be better, according to his skill and character.

Now let me, as soon as possible, expose the absurdity of a mischievous letter, which I fear may already have done much harm, but I hope my warning may do something to counteract its effects. I quote from the Blue Book so often mentioned: pp. 330-1.

MR. WILLIAMS *to* MR. DAY.

U. S. S. BALTIMORE, MANILA BAY,
July 2nd, 1898.

SIR,

* * * * * *

If long occupation or possession on the part of our government be considered, I believe early and strenuous efforts should be made to bring here from the United States men and women of many occupations—mechanics, teachers, ministers, shipbuilders, merchants, electricians, plumbers, druggists, doctors, dentists, carriage and harness makers, stenographers, typewriters, photographers, tailors, blacksmiths, and agents for exporting, and to introduce American products, natural and artificial, of many classes. To all such I pledge every aid, and now is the time to start. Good government will be easier the greater the influx of Americans.

My despatches have referred to our present percentage of export trade. If now our exports come here as interstate, duty free, we have practical control of Philippine trade, which now amounts to many millions, and because of ingrafting of American energy and methods upon the fabulous natural and productive wealth of these islands, can and probably will be multiplied by twenty during the coming twenty years. All this increment should come to our nation and not go to any other.

* * * * *

I hope for an influx this year of 10,000 ambitious Americans, and all can live well, become enriched. . . .

(Signed) O. F. WILLIAMS,
Consul.

I venture to say that the man who wrote this astonishing letter, taking upon himself the responsibility of advising "early and strenuous efforts" to send from the United States thousands of men and women of many occupations to Manila, and of assuring them that "all could live well and become enriched," knew nothing at all about the state of the Philippine Islands, and is a most unsafe guide.

What on earth would all these tradespeople find to do in the islands? Where could they be housed? How could they be supported? If they came in numbers, the doctors and druggists might indeed find full employment prescribing and making up medicine for the many sufferers from tropical ailments, especially the typhoid fevers, that would attack the unacclimatised immigrants, and the ministers could earn their daily bread by reading the burial service, whilst the typewriters would be busy typing letters to friends at home announcing the deaths that occurred; and warning them against coming to starve in Manila. But

I defy anyone to explain how the shipbuilders, electricians, plumbers, tailors and blacksmiths are to make a living. As regards merchants or agents for exporting, I may say that Americans have not been very successful in Manila in this capacity. The great and influential firm of Russell & Sturgis came to grief through over-trading, and another noteworthy firm, Messrs. Peele, Hubbell & Co., failed from rash speculations in sugar, and not from any persecutions by the Spanish authorities, as has been falsely stated in a magazine article. I speak with knowledge on the matter, as I was well acquainted with this firm, having been their consulting engineer for the construction of the slipway at Canacao for which they were agents. I think it only right to say that the gentlemen who were heads of these American firms were worthy upholders of the high reputation of their country. They failed, but no imputations rested on the characters of the partners, and I have always heard them spoken of with great respect, especially amongst the natives.

Those of them who were personally known to me were men who invariably showed every courtesy and consideration to all who came in contact with them, whether Europeans or natives. Notwithstanding their misfortunes they were a credit to their country, and they did a good deal towards the development of the trade in the Philippines.

I believe that the estates of Russell & Sturgis when realized, paid all their liabilities in full, and besides left considerable pickings in the hands of the liquidators and their friends. Two or three firms were built up out of their ruins. Some Chinese half-castes and natives had received heavy advances from this firm, especially about Molo and Yloilo. One well known individual had received $60,000, and when summoned before the court he claimed the benefit of the "Laws of the Indies," by which his liability was limited to $5. The judge, however, ordered him to repay the principal *at the rate of a dollar a month!* I had this information from the judge himself.

Curiously enough, American merchants have been equally unsuccessful in other parts of the far East. Many will remember the failure of Messrs. Oliphant & Co., the great China merchants, agents for the American Board of Missions, notwithstanding their desperate effort to retrieve their position by reviving the coolie trade with Peru, and in later days Messrs. Russell & Co. of Hong Kong also came to grief.

I can give no explanation of the reasons for these four great fail-

ures, but I conjecture that all these firms were in too much of a hurry, and tried to "hustle the East." Yet in face of this calamitous experience, Oscar F. Williams advises more to come, "pledges every aid," and predicts that "trade can, and probably will, be multiplied by twenty during the coming twenty years."

For my part, I should think it great progress if the exports and imports of the Philippines could be doubled in twenty years. The idea of sending plumbers to Manila where lead pipes are not used, is a comicality only matched by the suggestion that tailors are wanted amongst a population dressed in cotton shirts and trousers, and where the white people wear veranda-made white duck suits.

Both notions are more suitable for a comic opera than for an official document.

There is only one more paragraph in this letter that I need comment on.

Mr. Williams says: "Good government will be easier, the greater the influx of Americans."

To those who know the East there is no necessity to argue on this point. I therefore state dogmatically that the presence of white settlers or working people in the islands would add enormously to the difficulties of government. This is my experience, and during the Spanish administration it was generally admitted to be the case.

In British India the government does not in the least degree favour the immigration of British workmen. The only people who are recognised as useful to that country are capitalists and directors of agricultural or industrial enterprises.

A large number of American mechanics turned loose amongst the population would infallibly, by their contempt for native customs, and their disregard of native feeling, become an everlasting source of strife and vexation. Impartial justice between the parties would be unattainable; the whites would not submit to be judged by a native magistrate, and the result would be a war of races.

It may be taken as probable that there is no crime, however heinous, that could be committed by an American upon a native, that would involve the execution of the death penalty on the criminal. On the other hand, I can quite believe that natives laying their hands upon Americans, whatever the provocation, would be promptly hanged, if they were not shot down upon the spot. The natives, it should be re-

membered, are revengeful, and will bide their time; either to use the bolo upon one who has offended them, to burn down his house, set fire to his crop, or put a crow-bar in amongst his machinery. I fear that American brusqueness and impatience would often lead to these savage reprisals.

I think, therefore, that the American Administration of the Philippines should be empowered to prevent or regulate the immigration of impecunious Americans or Europeans whose presence in the Islands must be extremely prejudicial to the much-desired pacification. No, the poor white is not wanted in the Islands, he would be a curse, and a residence there would be a curse to him. He would decay morally, mentally, and physically. The gorgeous East not only deteriorates the liver, but where a white man lives long amongst natives, he suffers a gradual but complete break-up of the nervous system. This peculiarity manifests itself amongst the natives of the Far East in the curious nervous disorder which is called mali-mali in the Philippines and sakit-latah amongst the Malays of the Peninsula and Java. It seems to be a weakening of the will, and on being startled, the sufferer entirely loses self-control and imitates the movements of any person who attracts his attention. It is more prevalent amongst women than men. I remember being at a performance of Chiarini's Circus in Manila, when General Weyler and his wife were present. The clown walked into the ring on his hands, and a skinny old woman amongst the spectators who suffered from the mali-mali at once began to imitate him with unpleasing results, and had to be forcibly restrained by the scandalised bystanders.

Running *amok* marks a climax of nerve disturbance, when the sufferer, instead of committing suicide, prefers to die killing others.

He usually obtains his wish, and is killed without compunction, like a mad dog.

Both natives and white residents are at times in rather a low condition of health, and if after exercise or labour they fail to get their meal at the proper time, when it comes they cannot eat. In its lighter form this is called *desgana* or loss of appetite, but I have seen natives collapse under such circumstances with severe headache and chills. This more serious form is known as *traspaso de hambre,* and is sometimes the precursor of fever and nervous prostration.

The Roman Catholic Church has had the wisdom to recognise and make allowance for the liability of residents and natives of the Philip-

pines to this serious disorder, and has relaxed the usual rules of fasting, as being dangerous to health.

Amongst the Europeans who have been long in the Islands, many are said to be "chiflado," a term I can only render into English by the slang word *cracked*. This occurs more particularly amongst those who have been isolated amongst the natives.

It is not easy to account for, but the fact is undeniable. I have heard it ascribed to "telluric influence," but that is a wide and vague expression. Perhaps the explanation may be found in the extreme violence of the phenomena of nature.

The frequent earthquakes, the almost continuous vibration of the soil, the awe-inspiring volcanic eruptions, with their sooty black palls of ash darkening the sky for days together, over hundreds of miles, the frightful detonations, the ear-splitting thunder, the devastating rage of the typhoons, the saturated atmosphere of the rainy season, and the hot dry winds of Lent, with the inevitable conflagrations, combine with depressing surroundings and anxieties to wreck the nerves of all but the strongest and most determined natures. If to all this the white resident or sojourner in the Philippines adds the detestable vice of intemperance, or even indulges in a liberal consumption of spirits, then instead of merely shattering his nerves, he is likely to become a raving maniac, for it takes much less whisky to bring on delirium tremens there, than it does in a temperate climate.

Long sojourn in some other lands appears to act in a different manner. In tropical Africa it seems to be the moral balance that is lost. The conscience is blunted if not destroyed, the veneer of civilisation is stripped off, the white man reverts to savagery. The senseless cruelties of Peters, Lothaire, Voulet, Chanoine, and of some of the outlying officials of the Congo Free State are not mere coincidences. They must be ascribed to one common cause, and that is debasement by environment. The moral nature of a white man seems to become contaminated by long isolation amongst savages as surely as the physical health by living amongst lepers.

If a poor white man wishes to sink to the level of a native, he has only to marry a native woman, and his object will be fully attained in a few years. But he will find it very much to his pecuniary interest, for she will buy cheaper and sell dearer than he can, and will manage his house and his business too, most economically. Some of her relations will come and live with him, so that he will not feel lonely, and

a half-caste family will grow up round about him, talking the dialect of their mother, which he, perhaps, does not understand. But if the poor white man takes out a white wife, he will probably have the pain and distress of seeing her fade away under the severity of the climate, which his means do not permit him to alleviate. White women suffer from the heat far more than men. Children cannot be properly brought up there after the age of twelve. They must either be sent home to be educated, or allowed to deteriorate and grow up inferior to their parents in health, strength, and moral fibre. When I think of these things, I feel amazed at Oscar F. Williams' presumption in writing that letter. I hope that not many have taken his advice, and that any who have will call on him to fulfil his imprudent pledges.

However, now I have done with the poor white man. Capital is the greatest necessity of the Philippines. The labour is there if Generals Otis and McArthur have left any natives alive.

More banks are wanted. At present there are three important banks in Manila, and two of them have branches in Yloilo. The Hong Kong and Shanghai Banking Corporation has the largest resources; next comes the Chartered Bank of India, Australasia, and China, and lastly the Banco Español Filipino. The first two give the most perfect facilities for business. I was only interested in importing, but certainly nothing more could be desired by an importer than their system of opening credits against shipping documents; for practically he only had to pay for the goods when they arrived in Manila. All their business was done in the most expeditious manner, and I could suggest no improvement on their methods.

The Banco Español Filipino was in a measure under government control, its procedure was consequently very slow, and its ways those of bygone days.

These banks, however, did not advance money to cultivators to clear lands, plant crops, or erect machinery, as the returns are too slow, not to say doubtful. Yet this is what is wanted; banks in Manila and the chief towns that will advance money for such purposes, under the advice of experts personally acquainted with the cultivators and their lands. Such a business certainly requires great intelligence and discernment.

Still there is a future for such banks, for agriculturists have to pay enormous rates of interest and commissions for money to carry on their plantations. Such banks could also finance timber-cutters, gold miners, and other *bona fide* workers.

Amongst the enterprises I have recommended when writing about the Pampangos, and others engaged in planting sugar-cane, is the establishment of central sugar factories in suitable localities. Such undertakings, judiciously administered, would have every prospect of success.

There is also room for paper-mills, rice-mills, cotton-mills, and saw-mills, but all these, especially the last, need careful consideration for the selection of the locality where they are to be placed. The manufacture of various kinds of leather could be greatly extended and improved. There is employment for more coasting steamers and schooners. The latter and hulls of small steamers can be built in the country from the native timber.

Although the development of means of communication is all-important, it is evident from the configuration of the Archipelago that no great length of railway is required, nor would it pay to construct them in so mountainous a country. Water-carriage is all-important. In Luzon a line of railway might be made from Manila to Batangas with a branch into the Laguna province. It would traverse a fertile and thickly-populated country.

A short line of railway or electric tramway from near Siniloan on the Lake to the Pacific would be most useful in giving access to and developing the eastern coast, or contra costa, as it is called. This coast is very backward in every way, indeed from Baler to Punta Escarpada on its extreme north, it is quite unknown, and remains in the possession of the Dumagas, an aboriginal tribe of heathen savages of low type, just as at the time of the Spanish conquest; and it would be worth while to study the question of cutting a ship-canal through this narrow strip of land if the mouth could be protected from the Pacific surf. There is also Bishop Gainza's project that might be revived, that of cutting a canal for country craft from Pasacao in Camarines Sur to the River Vicol. In Negros and Panay some short lines from the ports through the sugar lands might pay if constructed very economically.

Tramways between populous towns not far apart in Luzon and Panay would probably pay very well, as the people are fond of visiting their friends.

It will probably be many years before Mindanao will be in a position to warrant the construction of railways. The island has relapsed into barbarism as a consequence of the withdrawal of the Spanish garrisons and detachments, and of nearly all the Jesuit missionaries.

It could, however, give employment to a flotilla of small steamers and sailing vessels on its northern and southern coasts.

Such is my opinion in brief upon the possibilities of the development of industries and commerce.

That the commerce of the islands, now mainly British, will ultimately pass into American hands, can scarcely be doubted. They are not yet firmly seated in power, but their attitude to British and foreign firms is already sufficiently pronounced to allow an observant onlooker to make a forecast of what it will be later on.

Dominating Cuba, holding the Philippines, the Sandwich Islands and Porto Rico, the Americans will control the cane sugar trade, the tobacco trade, and the hemp trade, in addition to the vast branches of production they now hold in their hands.

LIFE AND CHARACTER OF THE TAGALS

The most important race in the Archipelago is the Tagal, or Tagalog, inhabiting Central Luzon, including the following provinces:

Batangas, Bulacan, Bataan, Camarines Norte, Cavite, Laguna, Manila, part of Nueva Ecija and Tayabas, the districts of Infanta, Morong, and part of Principe, also the Island of Corregidor and the coast of Mindoro. They probably number about one million five hundred thousand souls.

Antonio de Morga, in his work "Sucesos de Philipinas," says (p. 126): "The women wear the báro and saya, and chains of gold upon their necks, also bracelets of the same. All classes are very clean in their persons and clothing, and of good carriage and graceful (*de buen ayre y gracia*")."

They are very careful of their hair, washing it with gogo and anointing it with ajonjoli oil perfumed with musk.

In the "Relacion de las Islas Philipinas," 1595 (?), the anonymous author said of the Tagals: "The people of this province are the best of all the Islands, more polite, and more truly our friends. They go more clothed than the others, the men as well as the women. They are light-coloured people of very good figures and faces, and like to put on many ornaments of gold, which they have in great abundance."

In other respects, however, they seem, from the same author, to be less worthy of praise, for he goes on to tell us: "When some principal man died, in vengeance of his death they cut off many heads, with

which they made many feasts and dances. . . . They had their houses full of wood and stone idols, which they called Tao-tao and Lichac, for temples they had none. And they said that when one of their parents or children died the soul entered into one of these idols, and for this they reverenced them and begged of them life, health, and riches. They called these idols *anitos,* and when they were ill they drew lots to find which of these had given them the illness, and then made great sacrifices and feasts to it.

"They worshipped idols which were called Al Priapo Lacapati, Meilupa, but now, by the goodness of God, they are enlightened with the grace of the Divine Gospel and adore the living God in spirit."

The old writer then remarks on the cleverness and sharpness of the boys, and the ease with which they learned to read and write, sing, play, and dance.

This characteristic appears general to the Malay race, for, speaking of the Javanese, Crauford says: "They have ears of remarkable delicacy for musical sounds, are readily taught to play upon any instrument the most difficult and complex airs."

According to Morga, at the time of the Conquest, the Tagals wrote their language in the Arabic language. He says: "They write well in these Islands; most people both men and women, can write. This tends to show that the equality of the sexes, which I shall refer to later, has been customary from ancient times."

Tomas de Comyn (1810) says:

The population of the capital, in consequence of its continual communication with the Chinese and other Asiatics, with the sailors of different nations, with the soldiers, and with the Mexican convicts who are generally mulattoes, and who arrive in some number every year, has come to be a mixture of all the bloods and features, or otherwise a degeneration of the primitive race.

At Cainta, on a branch of the Pasig, the natives are darker, taller, and of a different type. This is accounted for by the fact that, in 1762-63, during the English invasion, a regiment of Madras Sepoys, occupied the town for many months, long enough, in fact, to modify the native type to such an extent as to be plainly visible 125 years later.

Crauford says that some Christian inhabitants of Ternate followed their priests (Jesuits) to Luzon when the Spaniards were driven out of Molucas by the Dutch in 1660. They were located in Marigondon. There is now a town called Ternate between Marigondon and the sea,

near Punta Restinga. But, with the exception of the capital and these two places, I think the Tagals have not greatly altered in physical characteristics since the Conquest—notwithstanding Ratzel's statement that "Spanish-Tagal half-breeds in the Philippines may be numbered by the hundred thousand," which I consider erroneous.

The fact is, that wherever a small number of male Europeans live amongst a native race, the effect on the type is smaller than may be supposed, and what there is becomes obliterated or disseminated in course of time. Colour may be a little altered, but all the other characteristics remain. The mestizas are not so prolific as the native women, and notwithstanding Jagor's assertion to the contrary, they often marry natives, and especially if their father has died while they were young. I knew in the town of Balayan three handsome sisters, daughters of a Spaniard who had died many years before. Although they lived in a house which had been at one time the finest in the town, and still retained some remnants of its former grandeur, they had reverted entirely to the native customs and dress. They spoke only Tagal, and all three of them married natives.

The tendency of the Philippine native to revert to old customs is well marked, and I agree with Jagor when he says: "Every Indian has an innate inclination to abandon the hamlets and retire into the solitude of the woods, or live isolated in the midst of his own fields," in fact to *Remontar.*

The Tagals are considered by Wallace as the fourth great tribe of the Malay race. He only mentions the Tagals, but in fact the population of the Archipelago, except the Negritos and some hybrids, belongs to the Malay race, although slightly mixed with Chinese and Spanish blood in a few localities. They are here and there modified by mixture with other races, and everywhere by their environment, for they have been Roman Catholics and subject to Spanish influence, if not rule, for upwards of three centuries.

They differ little in physical appearance from the Malays proper inhabiting the Peninsula, and although their manners and customs are somewhat changed, their nature remains the same. They retain all the inherent characteristics of the Malay.

The Tagal possesses a great deal of self-respect, and his demeanour is quiet and decorous. He is polite to others, and expects to be treated politely himself. He is averse to rowdiness or horse-play of any kind, and avoids giving offence.

Family Life.

For an inhabitant of the tropics he is fairly industrious, sometimes even vary hard working.

Those who have seen him poling *cascos* against the stream of the Pasig will admit this.

He is a keen sportsman, and will readily put his money on his favourite horse or game-cock; he is also addicted to other forms of gambling. The position taken by women in a community is often considered as a test of the degree of civilisation it has attained. Measured by this standard, the Tagals come out well, for amongst them the wife exerts great influence in the family, and the husband rarely completes any important business without her concurrence.

Crauford considers the equality of the sexes to be general throughout the Indian Archipelago, more particularly in the Island of Celebes, where the inhabitants are the most warlike of all.

The Tagals treat their children with great kindness and forbearance, those who are well-off show much anxiety to secure a good education for their sons, and even for their daughters.

Parental authority extends to the latest period in life. I have seen a man of fifty years come as respectfully as a child to kiss the hands of his aged parents when the vesper bell sounded, and this notwithstanding the presence of several European visitors in the house.

Children, in return, show great respect to both parents, and come morning and evening to kiss their hands. I may remark that their manner of kissing is different to ours. They place the nose and lips against the cheek or hand of the person to be saluted, and draw in the breath strongly.

Appearance—Manners.

The Malays in general are not, perhaps, a handsome race, their flat noses disfigure them in the eyes of the recently-arrived European or American, and it takes time to get accustomed to them.

Still, their rich brown skin often covers a symmetrical, lithe and agile figure, the small hands and feet denoting their Turanian origin.

The youth of both sexes up to the age of puberty are not seldom of striking beauty, and their appearance is not belied by their behaviour. They are trained in good manners from their earliest youth, both by precept and example.

Palgrave says of them: "Nowhere are family bonds closer drawn, family affections more enduring, than amongst the Malay races. . . . His family is a pleasing sight, much subordination and little restraint, unison in gradation, liberty not license. Orderly children, respected parents, women subject, but not suppressed, men ruling, but not despotic, reverence with kindness, obedience in affection, these form a lovable picture, nor by any means a rare one in the villages of the Eastern Isles."

It may here be interesting to note the very contradictory opinions that have been expressed upon this subject.

JOHN FOREMAN	W. G. PALGRAVE
"The Philippine Islands," p. 194	"Malay Life in the Philippines," p. 146
"Home discipline and training of manners are quite ignored, even in the well-to-do families. Children are left without control, and allowed to do just as they please, hence they become ill-behaved and boorish."	"Children early trained by precept and example to good manners, show less disposition to noise and mischief than is ordinary elsewhere at their age."

As will be seen in my text, my own experience rather confirms Palgrave's opinion, and I should say that even the children of the peasantry would compare favourably both in manners and intelligence with the children at the Board Schools in London, and to say nothing of Glasgow or Liverpool.

Amongst the Tagals, it is customary when speaking of or to a man to use the prefix Si—thus, Si José, Mr. Joseph; whilst a woman is spoken of or to as Aling Maria, Miss Mary. The word Po is used for Sir. Thus: Oo-po—Yes, sir; Hindí-po—No, sir; Uala-po—There is none, sir; Mayroóm-po—There is some, sir.

Cleanliness.

The sense of personal dignity and self-respect, the dominant feeling in the Malay nature, is shown in the Tagals by a general cleanliness in their persons and clothing. They usually live near water, and nearly all of them can swim.

The heat of the climate makes bathing a pleasure, and as the temperature of the sea or river is commonly 83° F., a prolonged immersion causes no inconvenience.

On the morning of a feast-day the number of bathers is increased, and at the time of high tide a very large proportion of the population seems to be in the water, both sexes and all ages mixing indiscriminately, the adults decently covered and all behaving themselves as decorously as the bathers at Brighton, Newport or Atlantic City.

They have not yet arrived at that precise stage of civilisation that develops the Rough, the Larrikin, or the Hooligan. Palgrave says: "A Malay may be a profligate, a gambler, a thief, a robber, or a murderer, he is never a cad."

Palgrave had not great opportunities of knowing the Tagals, but I confirm the above opinion, although I do not agree with the views on the future of the Philippines, and what is best for them, expressed in his fantastic and hyphen-infested verbiage, all seemingly written for effect.

Superstitions.

The Tagal is extremely superstitious, and like his kinsman, the Dayak, he is a believer in omens, although he has not reduced them so completely to a system, and three centuries of Christianity have diverted his superstitions into other channels.

In his mind, each cave, each ravine, each mountain, each pool, each stream, has its guardian spirit, to offend or to startle which may be dangerous. These are the jinni of Southern Arabia and Socotra.

The Balete tree (*Ficus Urostigima*—Sp.) corresponds to our Witch Elm, and certainly at night has a most uncanny appearance. Each of these great trees has its guardian spirit or Tic-balan.

Daring, indeed, would be the Indian who would pass such a tree, enter a cave, ascend a mountain, or plunge into a pool without bowing and uttering the *Pasing tabi sa nono* [By your leave, my Lord] that may appease the spirit's wrath, just as the Bedouin of Dhofar cry, *"Aleik Soubera—aleik soubera,"* to propitiate the jinni.

His mental attitude in this respect reminds me of a story told me many years ago by a lady residing in Hampshire. A lady neighbour of hers inquired from her whether she taught her children to bow when the Devil's name was mentioned. My informant replied in the negative, whereupon the lady remarked, "I do, I think it is safer." This is the way with the Tagal, he bows because he thinks it is safer. If that prudent lady is still alive and may chance to read this, she may be pleased to learn that her opinion is shared by the whole Malay race.

Child-birth has its anxieties everywhere, and the more artificial the

life the woman has led, the more she suffers at that critical time. The Tagal woman whose naturally supple frame has never been subjected to tight-lacing, nor compressed within a tailor-made costume, has a far easier time of it than her European sister, but superstition and quackery combine to terrify and ill-use her.

The *Patianac,* an evil spirit, profits by the occasion, and his great delight is to obstruct the birth, or to kill and devour the infant. The patianac might be busy elsewhere, but from the ridge-pole of the house a bird of ill-omen, the dreadful Tic-tic, raises a warning cry, for its office and delight is to call the attention of the evil spirit to the opportunity of doing mischief. Instantly every door and window is closed and every chink stopped to prevent its entrance, whilst the anxious father and his kinsmen, naked as they were born, walk around and underneath the house, slashing the air with sticks or bolos to frighten away the spirit. Sometimes a man will get up on the ridge-pole to drive away the Tic-tic.

Meanwhile, in the stifling room, it is too often the case that violent means are used to expedite the birth, so violent, indeed, that they sometimes result in the permanent injury or in the death of the woman.

Several years ago the Government instituted an examination for midwives, and only those were allowed to practice who had been properly instructed, so that these absurdities and cruelties are on the wane, except amongst the poorest or in outlying districts.

The Asúan is merely a cannibal ghost, but the Tagal ghost throws stones, a thing I have not heard of a ghost doing in Europe.

All sorts of stories are told about the Asúan, similar to ghost stories in other lands.

About 1891 a house in Malate was stoned night after night, and although every effort was made to find out the authors, they were never discovered, and the natives steadfastly believed it to be the doing of the Asúan.

There is another superstitious idea firmly rooted in the minds of the Tagals and other natives, of which the following is an instance: A villainous-looking native had been captured with some property stolen from my house, and was sent to the lock-up at the police station, from whence he promptly escaped, but was recaptured later. My coachman, a most meritorious servant who had been with me for years, assured me in an impressive manner, and with an air of conviction, that the culprit was one of those wizards who are able to pass through a keyhole

by drawing themselves out into the thinness of a piece of string, and my other servants accepted this view implicitly.

The famous Tulisanes, or bandits, thoroughly believe in the power of the Antin-Antin or amulet to render them invulnerable to bullets. It is, indeed, remarkable that notwithstanding the numbers of these criminals who have been shot by the Guardia Civil with their Antin-Antin upon them, this absurd belief should flourish, but there is no doubt it does. These charms consist of any sort of necromancer's rubbish, or are sometimes writings in invocations, usually worn round the neck under the clothing.

The profession of the Roman Catholic religion has perhaps helped this superstition to linger on, for the wearing of scapularies is common, especially amongst the women. These articles are manufactured for the priests and some are sent out to Antipolo, to be blessed at the shrine of Nuestra Señor de Buen Viage y de la Paz, and sold to the pilgrims who crowd in thousands to this shrine in May of each year.

A Tagal woman sometimes wears as many as three of these scapularies hung from silk threads round her neck and covered by her upper garment. They usually dispose two in front, where they conceive the danger is greatest, and one on the back, as a further precaution against an attack from the rear.

Wearing these holy amulets, and having crossed herself and uttered a prayer before coming downstairs in the morning, the Tagal wife or maid feels that she has done all she can, and that if any backsliding should occur, during the day, it will not be her fault.

She believes greatly in lucky or holy numbers. I heard the following story related by a native lady to a native priest when going to Batangas by steamer.

The lady was telling the priest of her husband's illness (it appeared to have been congestion of the lungs), and she prepared and applied a poultice of three heads of garlic in honour of the Three Persons of the Blessed Trinity; this not producing the desired effect, she then made a poultice of five heads of garlic, in honour of the Five Wounds of our Blessed Saviour, and successively others of seven heads, in honour of the Seven Pains of the Blessed Virgin; twelve heads in honour of the Twelve Apostles, and last of all, a poultice of thirty-three heads of garlic in honour of the thirty-three years our Blessed Saviour remained on earth. The priest nodded approval as she went on, but as she stopped he said: "And then?" To which the lady replied: "Then he died."

This poor man came off easily, for in some cases people who suffer from fits and other diseases are thought to be possessed by devils, and are severely beaten to drive out the evil spirit. The patient does not always escape with his life.

The women often dream of lucky numbers in the Manila Lottery and make every endeavour to purchase the number they have dreamt of.

Amongst the Christian superstitions may be mentioned the feast of San Pascual Bailón at Obando. Those who attend this function are commonly the rowdier class of inhabitants of the Capital, and they go mostly on foot, making music and dancing on the way. They also dance in the courtyard in front of the church, not forgetting to refresh themselves with strong drink in the meanwhile.

This is not at all an edifying spectacle, for the dancers are covered with dust and with the perspiration from their active exertions. I do not know the legend that gives occasion to this curious form of devotion. Occasionally, and especially during Holy Week, another form of penitence is practised by the natives. I remember, about 1892, seeing one of these penitents, a man having a mask on his face, the upper part of his body bare, and a long chain fastened to one ankle and dragging on the ground behind him. In one hand he bore a flagellum, with which he from time to time lashed himself on the shoulders, which bore evident marks of the discipline they had received. A youth who followed him occasionally jerked the chain, throwing the penitent violently at full length upon the dusty road. This form of penitence is not approved, however, by the priests, for when I called on the parish priest, the same evening, I mentioned the circumstance to him, and he directed the penitent to be locked up, to stop what he rightly termed a scandal.

On many occasions the natives had got up a religious excitement, and great gatherings have taken place at some spot where a miraculous appearance of the Blessed Virgin, or some supernatural manifestation has been alleged to have occurred.

All these affairs have been somewhat sceptically inquired into by the priests under a general order to this effect issued by the archbishop, and so far as my experience goes, the excessive religious ardor of the natives has rather been checked than stimulated.

When writing about the Visayas I shall have more to say about misdirected religious zeal. The Tagals practise circumcision as a hygienic measure, and not as a religious rite. The operation is usually performed at the age of fourteen by a companion or friend of the

patient, and a sharp flint or piece of volcanic glass (obsidian) is used for this purpose. From what I have heard, this custom is really maintained by the women, who refuse their favours to the uncircumcised of their own nation, though with foreigners they are more complaisant.

Cursing.

In cursing, the Tagal displays a directness quite worthy of the Anglo-Saxon. All his remarks are very much to the point, and would have earned the approval of the late lamented and reverend author of the Ingoldsby Legends. Leaving out the world-wide reflections upon the virtues of an opponent's female ancestry, since these appear to belong indiscriminately to all nations, the principal Tagal curses are as follows:—

1. May an evil wind blow upon you.
2. May the earth open and swallow you up.
3. May the lightning strike you.
4. May the alligator eat you.

The superiority of the Tagal style as compared with the French Mortbleu, Ventre bleu, must be apparent to all unprejudiced observers. The Tagal has drawn all his curses from the grand and awful operations of nature in his own country, except the last, where he invokes the dreaded saurian, the most fearsome inhabitant of the Philippine swamps, rivers, and coasts—formerly venerated by his ancestors and respectfully addressed by them as *nono,* or grandfather.

Under American guidance and example, I think the Tagals quite capable of developing a startling vocabulary of swear-words, and in course of time rivaling their instructors in profanity, with a touch of their old style to give a little local colour.

Courtship.

Courtship is sometimes a long business amongst the Tagals. It is still customary in the country districts for the impecunious candidate for matrimony to serve the father of the damsel he desires to wed for a period which may extend to a couple of years or more. He is called a Catipado, and is expected to make himself generally useful, and to take a hand in any labour that may be going on, sowing or reaping, mending the roof; or patching the canoe.

It is his privilege to assist the girl of his choice in her labours. The girls of a household are expected to husk the rice for the next day's use. This is done in the cool of the evening, out of doors, a wooden mortar and a long heavy pestle being used. It is a well-recognised occasion for the lover to assist and entertain his sweetheart.

Very pretty do the village maidens look, as, lightly clothed in almost diaphanous garments, they stand beside the mortars plying the pestle, alternately rising on tiptoe, stretching the lithe figure to its full height and reach, then bending swiftly to give force to the blow.

No attitude could display to more advantage the symmetry of form which is the Tagal maiden's heritage, and few sights are more pleasing than a group of these tawny damsels husking paddy midst chat and laughter, while a tropical full moon pours its effulgence on their glistening tresses and rounded arms.

Marriage.

But let us return to the Catipado. He must be very careful not to give cause of offence to the elders of the family, more especially towards the end of his term, as there may be a disposition amongst them to dismiss him, and take on another to begin a new term. In fact, many natives have shown themselves so unwilling to consent to their daughter's marriage, when no sufficient reason could be given for their refusal, that the Governor-General, representing the Crown, is entrusted with a special power of granting the paternal consent in such cases.

No regular marriage can be celebrated whilst the girl is a minor, without the father's consent.

When this is refused, and the patience of the lovers is exhausted, the girl leaves her father's house and is deposited in the house of the fiscal, or churchwarden, under the care of his wife.

A petition on stamped paper is then prepared, reciting the circumstances; this goes to the parish priest and to the Gobernadorcillo, who require the father to state the grounds of his refusal. If they are satisfied that no good reason exists, the petition, with their approval noted on it, goes to the Governor-General, and in due time a notification appears in the official Gazette that the Governor-General has been pleased to overrule the father's negative, and a license (on stamped paper also) for the marriage to be celebrated, is delivered to the priest. This procedure is very necessary, but it has the disadvantage of being slow and expensive, so that in some cases, instead of adopting this course, the youthful pair allow themselves some advances of the privileges of matrimony, and perhaps there arrives a time when the obdurate parent finds himself obliged to consent to legalise an accomplished fact to avoid an open scandal.

The erring damsel, however, may think herself lucky if she escapes a fatherly correction, laid on with no grudging hand, before the reluctant consent is granted.

The priest will, of course, require the youthful sinners to confess and do penance for their previousness before he will marry them.

The marriage ceremony is a very simple one, and usually takes place after early Mass. The priest fixes the fee according to the means of the party; it is often a substantial one. After the ceremony comes a Catapúsan, or assembly, when the relatives and friends are entertained. There will be music, and unless the priest disapproves of dancing, that will be indulged in. The Augustinians mostly allow dancing, but the Dominicans often object to it as an immoral amusement.

The house will be hung with bright-coloured cloths and paper lanterns; the table loaded with refreshments, both light and heavy.

Wedding Feasts

Roast pig is a standing dish at these feasts, the animal being roasted whole, on a spit over a fire made on the ground. A professional roaster superintends the operation, and the pig is brought to a fine even colour all over. Sometimes there are roast turkeys or roast mutton and kid, possibly beef cooked in various ways, surely fish of different kinds, fresh, salted, or smoked; the indispensable boiled rice or morisqueta, and an abundance of sweets, fruits in syrup, guava jelly, and Dutch cheese. There will be chocolate and perhaps coffee. As to drinks, besides some native brews, there will be Norwegian or German export beer, or Tennant's beer in stone bottles, square-face gin, and Spanish red wine (Vino Tinto).

Unlimited Buyo, cigarettes and cigars are provided. All these things are hospitably pressed upon all comers, especially upon any European present. If his politeness prevents his refusing this miscellaneous assortment, unless he is favoured with the digestion of an ostrich, he will rue it next day, and perhaps for several days. The worthy priest is naturally in the place of honour, and like the wise man he mostly is, he perhaps brings, slung under his habit, or sends beforehand, a capacious leather bottle, with a supply of generous wine direct from some convent vineyard on the peninsula, a pure natural wine, undefiled and unfortified by German industrial spirit. A tall and portly Augustine monk, in his spotless and ample white robes, presents a very imposing and apostolic appearance, and looks quite in his place at the head of the table. The host seldom sits down with his guests, but busies himself attending to their wants.

Tagals as Soldiers and Sailors

The houses of the well-to-do natives are large and airy, and are kept scrupulously clean under the vigilant eye of the mistress.

Hospitality is a characteristic of the Tagal. According to his means he keeps open house on religious feast-days or on family festivals, and readily invites to his table at any time travelers who may be passing through the town. Having enjoyed their hospitality on many occasions, I can testify to their kindness and liberality. They placed at my disposal their riding-ponies, vehicles or canoes, and did all in their power to show me anything remarkable in their neighbourhood.

The Tagals make good soldiers, and can march long distances barefooted. Morga remarks how quickly they learned to use the arquebus or musket in the wars of the conquest. They gave proofs of their pluck and endurance when assisting the French in Tonquin. If well led they will advance regardless of danger; when once engaged they become frenzied and blood-thirsty, most difficult to restrain. They are not improved by being made to wear gloves, boots, helmets, and European uniforms.

In this they are not singular, for the Ceylon Rifle Regiment (a Malay corps) was utterly ruined, and never did any good after being put into boots and gloves by some narrow-minded martinet.

As sailors they are unsurpassed in the East. They navigate their schooners and lorchas with much skill, although the rigging and outfit is seldom kept in thorough good order unless they have a Spanish captain.

They serve both as sailors and firemen in the fine flotilla of coasting-steamers belonging to Manila, and they manned all the smaller vessels of the Spanish navy in the Philippines.

Most of the British and foreign steamers in the far East carry four Manila men as quartermasters. They are considered to be the most skilful helmsmen. Their ability as mechanics is remarkable. They bear out entirely Morga's description of them: "Of good talent for anything they undertake."

They will, without any European supervision, heave down wooden sailing-vessels up to about 1,000 tons, and repair the keel, or strip, caulk, and re-copper the bottom. I have often seen this done. They build, from the excellent hard wood of the country, brigantines, schooners, lorchas, also cascos, and other craft for inland navigation and

shallow waters. These latter vessels are most ingeniously contrived, and admirably adapted to the conditions under which they are to be used, and although not decked, carry their cargoes dry, and in good order, in the wettest weather. They make the most graceful canoes, and paddle or punt them with remarkable dexterity.

In Manila and Cavite are to be found a fair number of native engine-fitters, turners, smiths and boiler-makers.

There must be some 400 steam sugar-mills in the islands (besides 6,000 cattle-mills). The engine-drivers and firemen are all natives, and mostly Tagals.

There are also in the capital large numbers of native house-carpenters, quarrymen, stone-masons, and some bricklayers and brick-makers.

Curiously enough, foundry work is not much done by Tagals, although when Legaspi arrived in Luzon he not only found cannon mounted at Manila, but there was a cannon-foundry there, and another at Tondo.

There are foundries at the latter place to this day belonging to Chinese half-castes, but church-bells are more to their way now than cannon. They, however, cast small brass mortars with handles like quart pots, which are used for firing salutes at the feasts of the church. But I think most of the workmen were then, and are now, Chinese.

They make their own gunpowder, and fireworks of all kinds. They are inordinately fond of these, and get up very creditable displays. They are careless in handling them, and I was an eye-witness of an explosion of fireworks during a water fête, on the passing in front of the governor's palace at Malacañan, when a number of people were killed. I never learned how many had perished, and the newspapers were forbidden to enlarge upon it.

Excellent carriages are built in Manila entirely by native labour, the carromatas, or two-wheeled vehicles used for traveling, being made in the suburbs, or in Malabon.

Carriage-building is an important trade, for an incredible number of vehicles of all sorts are used in Manila.

Of an evening, in the Luneta, some hundreds may be seen, and on one occasion, at the races of the Jockey Club in Santa Mesa, two thousand vehicles were reported to be present.

Painting and decorating is executed by Manila men in excellent style. This art was taught them by Alberoni, and other Italians. Their pupils have covered the walls of many buildings with frescoes in the

Italian style, very fairly done. There is much scope for their art in decorating altars and shrines.

The Tagals also show some talent for sculpture, as any visitor to Manila can see for himself by inspecting the Jesuit Church, which is a marvel of patient artistic labour, having taken eleven years to construct. Some of the carving there, however, is so delicate and minutely detailed, that it appears more suitable for a show case in a museum than for the adornment of a place of worship. Of course, every detail of design is due to the Jesuits themselves, amongst whom talented men of every profession can be found.

As a fisherman, the Tagal excels, and the broad expanse of Manila Bay, some 700 square miles in area, gives ample scope for his ingenuity. He practises every kind of fishing, *Corrales de Pesca,* or fish-stakes within the five-fathom line, casting nets and seines in the shallow water, huge sinking nets attached to bamboo shear-legs mounted on rafts in the estuaries, drift nets and line-fishing in the deeper parts of the bay.

From Tondo, from Parañaque, Las Piñas, Bacoor, and Cavite Viéjo, and from dozens of other villages, go hundreds of large canoes, crowded with men, and heaped up with nets, to fish near the San Nicolas Bank, or about Corregidor Island, and they often return with large catches. Some fish by night, with torch and spear; in fact, they seem to be quite at home at any kind of fishing.

The nets and sails of the canoes, and the clothes of the fishermen are all tanned by them with the bark of the camanchile tree.

The salting, drying, or smoking of the fish caught in the bay is quite an extensive business. The smoked sardines, or tinapá, are very tasty, as also the pickled mullet roes called Bagón de Lisa. But the small shrimps, fermented in a jar and brought to a particular stage of putrefaction, much appreciated by the natives, will not suit European or American tastes.

The vast Bay of Manila holds fish and mammals of all sorts and sizes, from small fry to that huge but harmless monster of the deep, *Rhinodon tipicus,* with a mouth like the opening of a hansom cab, scooping in jelly-fish by the bushel.

The péje-rey, like a smelt, the lenguádo, or sole, the lísa, or mullet, the bacóco, corbína, pámpano, and others whose names I have forgotten, are excellent. The oysters are good, but very small. Prawns are excellent, large and cheap. Crabs are good, but large ones are not plentiful. Clawless lobsters are caught amongst the rocks of Corregidor and

Mariveles. The largest turtle I have ever seen was caught off Malabon. It can be seen in the Jesuits' Museum, Manila.

Sharks of all sorts, enormous saw-fish, hideous devil-fish, and monstrous conger eels, as well as poisonous black and yellow sea-snakes, abound, so that the fisherman does not have everything his own way. Amongst these men are to be found some excellent divers. I have found them quite able to go down to the keel of a large ship and report whether any damage has been done. Where a sheet of copper has been torn off, they have nailed on a new sheet, getting in two or three nails every time they went down. I enquired from one of these men who had frequently dived for me, when a European diver with diving-gear could not be obtained, if he was not afraid of sharks? He answered, "*No es hora del tiburon*"—it is not the sharks' time—and I found he considered that he was very fairly safe from the sharks between ten and four. Before ten and after four was a dangerous time, as the sharks were on the look-out for a meal. I cannot say that I should like to trust to this, especially as I have seen sharks about at other times, and one afternoon, in the bay, had to keep off a hammer-headed shark from coming near a British diver who was examining the rudder of a steamer, by firing at it from the stern. Some sharks are heavy and slow-moving creatures, but the hammer-headed kind are endowed with a surprising activity, and twist and turn like an eel.

My native diver informed me that he was much more afraid of the Manta than of any shark, and that once when he was diving for some purpose—I do not recollect when—at the bottom a shade fell on him, and, on looking up, he beheld an enormous manta right above him—in his words, "as big as a lighter." However, it passed on, and he was able to regain the surface.

Perhaps the most remarkable talent possessed by the Tagal is his gift for instrumental music.

Each parish has its brass band supplied with European instruments, the musicians generally wearing a quasi-military uniform. If the village is a rich one, there is usually a string band as well. They play excellently, as do the military bands. Each infantry battalion has its band, whilst that of the Peninsular Artillery, of ninety performers, under a bandmaster holding the rank of lieutenant, was one of the finest bands I have ever heard. There were few countries where more music could be heard gratis than in the Philippines, and for private dances these bands could be hired at moderate rates.

The Tagal is also a good agriculturist. According to his lights, he cultivates paddy with great care. It is all raised in seed-plots, the soil of which is carefully prepared, and fenced about. The fields are ploughed and harrowed whilst covered with water, so that the surface is reduced to soft mud. When the ground is ready for planting, the whole poulation turns out, and, being supplied with the young shoots in bundles, of which tally is kept, proceed to plant each individual shoot of paddy by hand.

Ankle-deep in the soft mud of the paddy-fields stand long rows of bare-legged men, women and children, each in a stooping position, holding against the body with the left hand a large bundle of rice-plants, incessantly and rapidly seizing a shoot with the right hand, and plunging it into the black slime with the forefinger extended.

Hour after hour the patient toil goes on, and day after day, in all the glare of the burning sun, reflected and intensified from the surface of the black water, till the whole surface has been planted. The *matandang-sa-naya*, or village elder, then announces how many millions of rice shoots have been put in. The labour is most exhausting, from the stooping position, which is obligatory, and because the eyes become inflamed from the reflection of the sun on the black water. As the paddy is planted during the rainy season, it often happens that the work is done under a tropical downpour instead of a blazing sun.

When driving along a road through paddy-fields in October, it seems incredible that every blade of that luxuriant crop has been transplanted by hand. Yet the people who do this are branded as lazy. I think that they are quite ready to work for a sufficient inducement. Whenever I had work to execute I never experienced any difficulty in obtaining men. I made it a rule to pay every man with my own hands every Saturday his full wages without deductions. On Monday morning, if I wanted 300 men, there would be 500 to pick and choose from. I should like to see some of their depreciators try an hour's work planting paddy or poling a casco up stream.

The undulating nature of the ground renders it necessary to divide paddy land into small plots of irregular outline at varying levels, divided from each other by ridges of earth called pilápiles, so as to retain the rain or irrigation water, allowing it to descend slowly from level to level till it reaches its outlet at the lowest point. The Tagals fully justify their Turanian origin by the skill and care which they show in irrigation. About Manila, the sacáte, or meadow-grass, which is the

principal food of the thousands of ponies in the city, is cultivated on lands which are exactly at a level to be flooded by the spring tides.

The mango-tree is carefully cultivated, and the fruit is, to some extent, forced by lighting fires of leaves and twigs under these trees every evening in the early part of the year to drive off insects, and give additional warmth.

In Batangas and La Luguna, and, to some extent, in Bulacan, the Tagals cultivate the sugar-cane successfully.

But where they really shine, where all their care is lavished, where nothing is too much trouble, is in the cultivation of the buyo (Piper betel). This is a climbing plant, and is grown on sticks like hops. There were many plantations of this near Pineda, which I frequently visited. It is grown in small fields, enclosed by hedges or by rows of trees to keep off the wind.

The soil is carefully prepared, and all weeds removed. As the tendrils grow up, the sticks are placed for them. The plants are watered by hand, and leaf by leaf carefully examined every morning to remove all caterpillars or other insects. The plants are protected from the glare of the sun by mat-shades supported on bamboos.

The ripe leaves are gathered fresh every morning, and taken to market, where they find a ready sale at remunerative prices for chewing with the areca nut and a pinch of slaked shell lime.

Whenever I have had Tagal hunters with me deer-shooting, I have been struck with their knowledge of the natural history of their locality. They thoroughly understood the habits of the game, and almost always foretold correctly the direction from which the deer would approach the guns.

They have names for every animal and bird, and for the different ages or conditions, or size of antlers, of the deer.

Even insects and reptiles are named by them; they could give details of their habits, and knew whether they were poisonous or dangerous.

They always showed themselves greatly interested in sport, and much appreciated a good shot. They spoke of a gun that killed well as a hot gun (baril maínit). If they were trusted with a gun they were very reluctant to spend a cartridge unless for a dead certainty. If two cartridges are given to a hunter, he will bring in two deer or pigs, otherwise he will apologise for wasting a cartridge, and explain how it happened.

Their usual way of taking game is to set strong nets of abaca in the woods in the form of a V, then the beaters and dogs drive the game towards the hunters, who are concealed near the apex, and who kill the deer or wild pigs with their lances whilst entangled in the nets.

I have found the Tagals very satisfactory as domestic servants, although not so hard-working as the Ilocanos. Some of them could clean glass or plate as well as an English butler, and could lay the table for a dinner party and ornament tastefully with flowers and ferns, folding the napkins like a Parisian waiter.

They could also write out the ménu (their orthography having been previously corrected), and serve the dinner and wines in due sequence without requiring any directions during the meal.

Some of them remained in my service the whole time I was in the Philippines. One of them, Paulino Morillo, came to England with me in charge of my two sons, and afterwards made three voyages to Cuba with me. I gratefully acknowledge his faithful service.

I did not find them sufficiently punctual and regular as cooks, nor did they make their purchases in the market to as much advantage as the Chinese cooks, who never bid against one another to raise the price.

As clerks and store-keepers I found the Tagals honest, assiduous, and well-behaved. As draughtsmen they were fairly skilful in drawing from hand sketches, and excelled in copying or tracing, but were quite untrustworthy in taking out quantities and computing. Some of them could write beautiful headings, or design ornamental title-pages. I have by me some of their work that could not be done better even in Germany or France. But the more skilful they were the more irregular was their attendance, and the more they had learned the worse they behaved.

When doing business with the Tagals, I found that the elder men could be trusted. If I gave them credit, which was often the case, for one or two years, I could depend upon the money being paid when due, unless some calamity such as a flood or conflagration had rendered it absolutely impossible for them to find the cash. In such a case (which seldom happened) they would advise me beforehand, and perhaps bring a portion of the money, giving a pagaré, bearing interest, for the remainder, and never by any possibility denying the debt. I never made a bad debt amongst them, and gladly testify to their punctilious honesty. This idea of the sacredness of an obligation seems to prevail amongst

many of the Malay races, even among the pagan savages, as I had occasion to observe when I visited the Tagbanúas in Palawan (Paragua). They certainly did not learn this from the Spaniards.

The More Instruction the Less Honesty

When dealing with the younger men who had been educated in Manila, in Hong Kong, or even in Europe, I found that this idea had been eradicated from them, and that no sufficient sense of honour had been implanted in its stead.

In fact, I may say that, whilst the unlettered agriculturist, with his old-fashioned dress, and quiet, dignified manner, inspired me with the respect due to an honest and worthy man, the feeling evolved from a discussion with the younger and educated men, dressed in European clothes, who had been pupils in the Ateneo Municipal, or in Santo Tomás, was less favourable, and it became evident to me that, although they might be more instructed than their fathers, they were morally below them. Either their moral training had been deficient, or their natures are not improved by education. I usually preferred to do business with them on a cash basis.

Unsuitable Training

Dare I, at the tail-end of the nineteenth century, in the days of Board Schools, County Councils, conscientious objectors, and Hooligans, venture to recall to mind a saying of that grand old Conservative, the Peruvian Solomon, Tupac Inca Yupanqui? "Science should only be taught to those of generous blood, for the meaner sort are only puffed up and rendered vain and arrogant by it. Neither should such mingle in the affairs of state, for by that means high offices are brought into disrepute."

That great monarch's words exactly express my conclusions about the young Tagals and other natives.

To take a young native lad away from his parents, to place him in a corrupted capital like Manila, and to cram him with the intricacies of Spanish law, while there is probably, not in all those around him, one single honest and upright man he can look up to for guidance and example, is to deprive him of whatever principles of action he may once have possessed, whilst giving him no guide for his future conduct.

He acquires the European vices without the virtues; loses his native modesty and self-respect, and develops too often into a contemptible *pica-pleito*, or pettifogger, instead of becoming an honest farmer.

The more educated Tagals are fond of litigation, and with the assistance of native or half-caste lawyers will carry on the most frivolous and vexatious lawsuit with every artifice that cunning and utter unscrupulousness can suggest. The corrupt nature of the Spanish courts is a mainstay to such people. Although they may be possessed of ample means litigants often obtain from the court permission to sue a foreigner in *forma pauperis.*

They are unscrupulous about evidence, and many will perjure themselves or bring false witnesses without shame. It is said that blank stamped paper of any year can be obtained for a sufficient price for the purpose of forging documents relating to the sale of land; as there are people who regularly keep it for this purpose.

The feeling of envy is strong within them, and any Spaniard or foreigner who appears to be succeeding in an industrial enterprise in the provinces, such as planting or mining, is sure, sooner or later, to be attacked by the pettifoggers or their men of straw, and he will be bled heavily when he comes before the courts, and perhaps have to go to the Court of Appeal or even to the Tribunal Suprémo in Madrid before he can obtain a verdict in his favour.

The credulity of the Tagal is remarkable; he has on occasion given way to outbursts of ferocity, involving death and destruction to numbers of innocent people.

In 1820, during an epidemic of cholera, he was led to believe that this strange sickness had been produced by the foreigners, who had poisoned the water. An indiscriminate massacre of foreigners was the consequence of this calumny, and but few escaped. The authorities, always prompt to repress uprisings against the Government, allowed time for the foreigners to be massacred before they interfered. It is not easy to say how many English, French, or Americans met their deaths at the hands of the populace, for such details are never allowed to be published.

I may say, however, that one should not be too hard on the Tagals for this crime, since at a much later date a massacre of priests occurred in Madrid, on account of a similar belief. It was started because a lad, the servant of a priest, was seen to throw some white powder into the Fuente Castellana. I have not at hand the details of this massacre, but the friars were slaughtered like pigs.

In the dreadful epidemic of cholera in 1882, the natives behaved very well, and I must give General Primo de Rivera credit for keeping

strict order and promptly organising the construction of temporary hospitals, the inspection of every parish of the city, the conveyance of the sick to hospital, and the burial of the dead. It was done under military direction, and with the assistance of the priests, the civil authorities, and the principal inhabitants. No disturbances occurred owing to the strong hand of the Governor-General, although some of the evil-disposed natives began to murmur about the doctors carrying about the disease.

The mortality was dreadful; I believe that some 30,000 people lost their lives in the city and province of Manila in three or four months. In order to nurse the sick and bury the vast number of dead, it was necessary to employ the convicts and prisoners. All these people behaved remarkably well, although many succumbed to the disease. The survivors were pardoned outright, or had their sentences reduced. If the Governor-General had shown signs of weakness, the horrors of 1820 might have been repeated.

To give a better idea of the credulity of the Tagals and other natives, I may say that in 1868 telegrams were received in Manila (viâ Hong Kong) which were made public in the islands, announcing the Spanish revolution of September, and the news, with stupendous exaggerations, reached the remotest villages and the most miserable huts. A general and indelible idea took possession of the minds of the natives that Revolution (they thought it was a new emperor or a great personage) had decreed that all were equal, that there should be no difference between Indians and Spaniards, that the latter had to return to Spain and Indians be substituted in all employments, and that the tribute would be greatly reduced. That there would be no conscription nor corvée (personal work), that the Pope would name several Indian bishops, and that the Spanish priests would return to the Peninsula. That a new captain-general would arrive who would marry a native lady, who would be made a princess, that their children would be kings and sovereigns of the Philippine empire.

All this was confirmed by prophecies, by dreams, and revelations, and great miracles by the Virgin of Antipolo and of St. Joseph, and other patrons of the Indies, not omitting St. Peter, for whom the native clergy profess a profound veneration, and who is the patron saint of a brotherhood which has caused much trouble in the Philippines.

General Gándara, informed of all these absurdities by the friars, did not fail to appreciate the immense importance of the movement

which, like the teachings of the so-called gods of Panay and Samar who collected thousands of followers, might produce a general insurrection. He therefore took due precautions, and invited all the Spaniards in the Philippines, without distinction of party, in support of the Government constituted in Spain. There was, however, much agitation and much traveling to and fro amongst the native clergy and the pettifogging lawyers. It was, however, not till 1872 that the conspirators succeeded in producing the mutiny of Cavite, which was quickly suppressed, with much slaughter of the mutineers.

The chief amusement of the Tagal is cock-fighting. I shall not describe this well-known sport, but will remark that it provides no inconsiderable revenue. The right of building and running the cock-pits of each province is farmed out to Chinese or Chinese half-breeds, and no combats may take place except in these places. They are opened after Mass on Sundays and feast-days, and on some other days by special leave of the authorities. The love of this sport and the hope of gain is so general that the majority of the natives of Manila are breeders of game-cocks, which they tend with assiduous care, and artisans often carry their favourite birds to their work and tether them in the shade, where they can keep them in view. Horse-fights occasionally take place. The ponies of the Philippines, although not usually vicious to man, will fight savagely with each other, and inflict severe bites.. I remember a case where two ponies harnessed to a victoria began fighting and a Guardia Civil attempted to separate them, when one of the ponies seized him by the thigh, lifted him off his feet, and shook him as a terrier might shake a rat; the flesh of the man's thigh was torn away and the bone left bare. This dreadful wound caused his death. The occurrence took place in front of the church of Binondo in Manila. Bull fights have been an utter failure in Manila, although many attempts have been made to establish them. Flying kites is a great amusement with young and old in the early months of the year, when the northeast monsoon blows. Fights are organised: the competing kites have crescent-shaped pieces of steel attached to the tails, and the competitor who can cut the string of his opponent's kite by causing his own to swoop suddenly across it, is the winner. Betting on the result is common. The Tagals are also fond of the theatre, and some years ago there was a Tagal theatre in Binondo where comedies in that language were played. I have also met strolling players in the country towns.

But of all kinds of shows a good circus is the one that fetches his

last dollar out of the Tagal. Guiseppe Chiarini reaped a silver harvest in Manila on both occasions he pitched his tents there. His advance agent, Maya, a Chilian, paved the way for success, and the pompous announcement that Chiarini was born in the sacred city of Rome, greatly impressed the natives, who flocked in thousands to his circus. Chiarini considered himself able to tame the most vicious horse, and purchased a fine Manila pony that no one could manage. The beast, however, was not subdued by his powers, and, seizing the tamer's cheek, bit off a large piece.

On feast-days in the larger towns, open-air plays are sometimes given, and what with preparations, rehearsals, and performance, absorb the attention of a large number of the inhabitants for a couple of months. I witnessed a very notable performance of this kind some years ago at Balayan, in the province of Batangas, the characters being played by the sons and daughters of the principal people there. The subject was taken from the "Wars of Grenada." In the first act we saw a Christian king and his court, also his only and peerless daughter. After these had had their say, an ambassador from the Moslem king was announced, and the king summoned his council to consider the communication. He took his seat upon the throne, with gray-bearded councillors on each side. The Moslem envoy, and his suite and escort, entered on horseback and very unnecessarily galloped about and gave an exhibition of their horsemanship. The envoy, still on horseback, harangued the king, and arrogantly demanded the hand of the beauteous princess for his master, threatening war to the knife in case of refusal. He then retired to his camp.

Next came the discussion of the demand, which the grey-beards think it hopeless to resist. The Moslem envoy was sent for, and amid great grief the princess was about to be confided to his care, when there rushed in a young Christian warrior and his followers, who swore they would never allow a Christian princess to wed a Paynim, and dismissed the envoy with contumelious remarks. He retired vowing vengeance. All this occupied a long time, and I did not remain for the rest. I think it took two days to act. But from the volleys of musketry and firing of rockets and mortars which I heard, a sanguinary war must have been waged and many of the characters must have perished. The play was acted in a more spirited way than usual; some of the male performers declaimed their parts with energy. Some were mounted on fine ponies, and were well got up and armed.

The girls' dresses were rich, and they wore a great deal of jewelry. Some of the princesses were very handsome girls. There is a sort of superstition that any girl performing in one of these pieces is sure to be married within a year. This makes them very ready to undertake a part, as they obtain an excellent opportunity to display their charms to advantage, and so help to fulfill the prediction. The play was witnessed by the mass of the population of Balayan and by numerous visitors from the neighbouring towns. It was considered a very successful performance, and it carried my memory over the wide Pacific to Peru, where I have seen similar plays acted by the country people in the Plaza of Huacho.

Tagal Literature

Tagal literature does not amount to very much, and the policy of the Government of late years has been to teach Spanish as well as the native dialects in the schools. This did not meet the approval of the old school of priests; but many of the younger ones have accepted the Government view. In the Exhibition of the Philippines, Madrid, 1887, Don Vicente Barrantes showed twenty volumes of grammars and vocabularies of the Philippine dialects, and thirty-one volumes of popular native poetry, besides two volumes of native plays. The Reverend Father Raimundo Lozano exhibited twenty-eight volumes of religious works in the Visayas-Panayano dialect, and the Reverend Father Francisco Valdez a study of the roots of the Ilocan dialect in manuscript. Many works in the native dialects have been written by the Spanish priests, such as one by the Reverend Father Manuel Blanco, the learned author of the "Flora Filipina," of which I give the title and the first verse:—

Tagaloc verses to assist in dying well.	"Manga dalit na Tagalog at pagtulong sa mamaluatay na tanang Cristiana."

Manila, 1867, VIII, 62 pag 8°.

"Aba bumabasa baquin baga caya
Tila camuntima i nata cang bohala."

I now give the title of a secular poem in English and Tagal, that the reader may compare the words and note the subject:—

Story of the life of the beauteous shepherdess Jacobina, a native of Moncada, who became the wife of the King, Policarpio de Villar, in the kingdom of Dalmatia, and bore a son named Villardo.

"Salita at buhay nang marilang na pastora na si Jacobina tubo sa Villa Moncada Naguing asáua nang Policarpio de Villar sa caharian nang Dalmacia nagga roon nang isang supligna anac ang pangaia i si Villardo."

The poem begins—

"O maamong Ester mananalong Judit
Mariang linanag nitong sang daigdig."

and concludes—

"Panang nang pupuri ang lahat nang cabig
Sa yanang inaguling ang tinamo i sangit."

I do not think it is necessary to quote any more, as this gives the reader sufficient idea of the language.

There is much that is good in the Tagal, much to like and admire. Antonio de Morga, Sinibaldo de Mas, Tomás de Comyn, Paul de la Gironière, Jagor, Bowring, Palgrave, Foreman, Stevens, Worcester—all have some good to say of him, and with reason. But the piratical blood is strong in him yet. He requires restraint and guidance from those who have a higher standard for their actions than he has. Left to himself he would infallibly relapse into savagery. At the same time he will not be governed by brute force, and under oppression or contumelious treatment he would abandon the plains, retire to the mountains, and lead a predatory life. Although not just himself nor truthful, he can recognise and revere truth and justice in a master or governor. Courageous himself, only a courageous man can win his respect. He is grateful, and whoever can secure his reverence and gratitude will have no trouble in leading him.

I have testified to the Tagal's excellence in many handicrafts and callings, yet I greatly doubt whether they have the mental and moral equipment for any of the professions. I should not like to place my affairs in the hands of a Tagal lawyer, to trust my life in the hands of a Tagal doctor, nor to purchase an estate on the faith of a Tagal surveyor's measurement.

I do not say that they are all untrustworthy, nor that they can never become fit for the higher callings, but they are not fit for them now,

and it will take a long time, and a completely changed system of education, before they can become fit.

What they want are examples of a high type of honour and morality that they could look up to and strive to imitate. There are such men in America. Whether they will be sent to the Philippines is best known to Mr. McKinley.

ARCHÆOLOGY

The Beginning of Archaeology may be said to have been made with the decipherment of the Rosetta stone. This was found at Rosetta in 1799. It contained three inscriptions, one in hieroglyphic, one in demotic and the other in Greek. There was reason to suspect that the three inscriptions were identical in meaning and with this clue scholars set to work to decipher the hitherto unknown hieroglyphics. Young and Gell made a good beginning and by 1832 Champollion had succeeded in deciphering all the inscriptions.

Before this result had been reached Grotefend made a substantial start at explaining the cuneiform characters of Mesopotamia by comparing the known names of Persian kings with cuneiform inscriptions he thought might contain the names. This gave the key, and Bournouf and Lassen (1836-1844) completed the short Persian alphabet. Next Rawlinson, from the trilingual inscription at Behiston in Persian, Assyrian, and Vannic worked out the great Assyrian syllable-system of six hundred signs.

Since this time Egypt and Mesopotamia have furnished magnificent fields for research into times hitherto lost below the horizon of history, and the date of the beginnings of civilization has been placed further and further back.

The relics of the Egyptian literature hidden in papyrus rolls belonging to the period from A. D. to 1000 B. C. have been deciphered. The Book of the Dead, showing the worship of Osiris, (see volume I) is one of the great finds of this period. Study of the remains of temples, tombs and towns has shown before this period and from 1000 to 1600

BLESSED DAMOZEL

B. C. the everyday life of a great empire. Anterior to this had come the invasion of the Hyksos; prior to the Hyksos the civilization of the twelfth dynasty (about 2600 B. C.); then back beyond a period of decay, the civilization of the Old Kingdom (4500-3500 B. C.) that built the grandest of the pyramids and monumental remains. This was preceded by the invasion of a people probably from the direction of the Red Sea (about 5000 B. C.), who brought with them much of the base of the civilization of the Old Kingdom; and dating probably from as early as 6000-5000 B. C. are found relics of a primitive Egyptian race that built towns of brick, used linen, leather, pottery, wood, ivory, copper, and polished flint.

The remains in Chaldea seem to be even more ancient. The religious literature given in the first volume dates further back than any literature of Egypt. Libraries of clay tablets seem to have been in existence before 3000 B. C. Researches have not been as extensive in the sites of towns as in Egypt and the oldest civilization is not as well known. We give below a summary of the facts of the Babylonian period.

In Greece, archæology has discovered the remains of high civilizations existing in the Mycenian age before the Doric invasion of about 1000 B. C. The earliest relics of civilization seem to go back to about 3000 B. C.

But archæology pushes its researches into the study of primitive man far back before the eras of even Chaldea or Egypt. The great ages of these countries correspond to the ages when men used bronze largely for weapons and ornaments (about 3000-1000 B. C.) and even to the age of copper (5000-3000 B. C.). The lake dwellers belonged to the latter period or even before. Prior to them there were workers in polished stone. The ages of the cave dwellers, who at the last were workers in bone, and at the first were rude shapers of stone, carry us back no man knows how many thousand or tens of thousand years.

F. E. PEISER

A SKETCH OF BABYLONIAN SOCIETY

THE PREPARATION of a history of Babylonian culture is surrounded with so many difficulties that only those but slightly acquainted with its aspects would dare to undertake the task. In fact, the most necessary preliminary studies have been begun only within the last few years. Historical works on the subject show a disregard or ignorance of the elements of the history of culture, while the preliminary works which have appeared lack more or less the bond of interrelationship. It is, therefore, not an unimportant work to give for a part of the history of culture an outline, or skeleton, about which the scattered and disconnected studies, thus far attempted, may rally, and thus make it possible to proceed more methodically in the consideration of individual questions.

For these reasons I have decided to condense several lectures written some years ago into the present publication, which neither claims completeness nor to pronounce the final word. On the contrary, I hope that sharp criticism will be aroused by this sketch, through which the common aim or object may be advanced. As this is really a sketch of the subject, I have refrained from citing and collating authorities which are to find their place in monographs to follow; and this also explains why I have taken up society as a unit, and scarcely more than indicated its development. The work is based mainly upon the conditions of Babylon in the sixth and seventh centuries before the Christian era. In going still farther backward, the task is to unravel the close-meshed fabric of Babylonian culture and to study the history of its development along the individual strands.

In the activity of thousands of years the Euphrates and the Tigris have built up from alluvial drift the territory between their arms. Sand and stones, stripped by the melting snow from the Armenian Mountain peaks, have formed deposits which pushed the Persian Gulf ever farther back toward the south and east. Thus we have in the south

a province with no mountainous formations, but only plains and hills of sand, with but few stones. The plain is traversed by the two rivers named, which differ in relative level at two points; at one place the water of the Euphrates flows over and feeds the Tigris, while 100 miles southward an equalization occurs by the reflux of the Tigris into the Euphrates.

If we consider the climate of the country, we find in the south, in the whole of Babylonia, the characteristics of the hot desert climate modified only by the moisture from the rivers. The desert extends up along the Euphrates and spreads far away beyond it over to Mesopotamia. Nevertheless we must form no false picture of the Mesopotamian desert. After heavy rains it is overgrown by vegetation with wonderful rapidity; and the traveler from the Occident is often amazed when, after the rain, the entire desert appears yellow with crocus plants or blue with other growths. At such times the Arabian nomads cross the Euphrates to pasture their cattle, and thus thousands of years ago strife arose between the residents and the invaders, which continued yet further during the historical development.

So far as historical notices accessible up to this time extend, there still remains the sole probability that in the south of the country traversed by the two streams, northward, eastward, and westward from the Persian Gulf, originally dwelt people of a race who used an agglutinative language, were characterized by a compact bodily frame, and were of a Mongoloid type. I do not wish to enter deeply into several much too radical theories concerning the Sumerians and their racial affinities; I would merely like to refer to the fact that I have already in my book, Hittite Inscriptions, called attention to the possibility of a connection between the so-called Hittites, non-Aryan proto-Armenians, and Sumerians, and that the ancient population of Elam might easily be included with these. But even in the earliest times Semites appear to the north of the district bordering on the Persian Gulf. As in the historical development between 2000 and 600 B. C., two invasions and settlements of Semitic nomads can be recorded, in which connection the theory advanced by Winckler concerning the Aramæans and the Chaldeans is especially to be noticed, it is very natural to assume also for these most ancient Semites a nomadic period, which had already ended when history begins to raise the curtain before our searching eyes.

The political supremacy of these oldest Semites introduced racial variations. We may look upon the invading Kassites from the Kas-

sæan mountains as a third element, which also for a time furnished the acknowledged rulers of Babylonia. The second wave of Semitic immigration, the Aramaic tribes, had begun in the time of the Kassu rule, and for centuries furnished the nomadic population of the steppes, against whom the population of the cities were engaged in struggle. The advances of the tribes and the retreats of the agricultural population were accompanied by ruins of dikes and canals until a strong hand again forced the nomads back and restored the water courses. These tribes became gradually settled and constituted the fourth racial element, as appears from several historical notices and from Assyrian contracts.

Finally, we must notice the pushing forward of the Semitic Kaldi tribes from the south, and the contemporaneous efforts of the Assyrians from the north to obtain the supremacy in Babylonia. But while the preceding four elements composed the basis or foundation out of and upon which ruling classes developed, these two latter parties formed external factors which influenced the social and political life of Babylon.

If we also mention as a potent external factor the Elamite monarchy, which endeavored to play off the Kaldi and the Assyrians against each other in their struggle for Babylon, we have briefly sketched the picture of the inhabitants, their origin, and those of their neighbors who come into consideration.

From these elements and their sediment was formed what we are accustomed to regard as the Babylonian state. We must not imagine an oriental state, however, as being any such firmly welded whole as are our modern European states. Race feeling operated in a manner altogether different from among us. There the whole life of the State was concentrated about great cult centers. Surface configuration, intercourse relations, and the coincident power of single provinces welded a greater political unit about a cult center. Thus was formed a political organization that perhaps soon after was merged into a larger unit, and left nothing but a name behind it in proof of its former existence. Among these political units we know of Sumer and Akkad, that is, the power once connected with Ur, the Kingdom of Babylon; also smaller ones in the north, such as the kingdom of "the four regions" and the Kingdom of Kisshat, of which the cult center is not yet precisely determined, but probably to be sought in northern Mesopotamia. Farther away from the proper center lies Elam, which had attained the rank of a State since primeval times. We see Assyria and farther to the north, the proto-Armenian tribes.

The political history of Babylon, even in the earliest times, presents an alternating picture of centralization and disintegration of the empires embodying the centralization. The question presents itself, what could have been the cause which in so remote a period again and again led to the consolidation of a great district, while as yet, in all neighboring provinces, with few exceptions, only a more or less feeble tribal bond could be formed. The answer may be inferred from the following circumstances:

(1) As soon as an individual by reason of the domination of one of the smaller commonwealths had succeeded in restoring the centralization after a period of its decay, his main efforts were especially directed toward the restoration of the neglected canals.

(2) During a decline of the central authority the canals became choked with sand.

(3) The Babylonians imagined the period of such political weakness to be a time of anger of the gods, who were deserting the country and giving the supremacy over to its enemies.

(4) The hydrographic conditions of the country of the two rivers were of such nature as in themselves to call for regulation and utilization. For, while the bed of the Tigris in its northern portion is lower than the Euphrates, so that the latter seeks an outlet toward the former during inundations, farther on, at the second confluence of the rivers, it is higher. This peculiarity, which apparently contradicts the fact that the Tigris in that part flows much more swiftly than the Euphrates, is explained by the fact that the former flows in a straight course, and thus has a much shorter distance to traverse than the Euphrates, which describes a large loop. And while the swifter course of the Tigris prevents it from choking its channel, the Euphrates at once covers its domain, its bed, and channels with its alluvial drift whenever a systematic regulation is not kept in continuous operation. It repeatedly fills its own channel, tears away the banks, and reduces the painfully acquired agricultural land to swamp and waste again.

In reply, then, to the inquiry as to the cause of this ever-reappearing centralization, it may be answered that the nomads who first settled in the country of the two rivers were compelled by the hydrographic conditions to regulate the river system; this regulation demanded and developed an administrative center; these conditions gave as a result the idea that the country belonged to the gods; and this idea had force to bring about a real centralization. Ideas continue in activity thousands of years after the conditions out of which they arose have altered. We must not be surprised, therefore, at finding this idea operative under later conditions; we may even use it as a clue to the complicated life of New Babylon.

If, now, we consider the State—I speak, of course, of the individual States in their inward and outward design—we have to regard two

factors: (1) The State centers about one focus of cult. For the Orient this cult center is of the greatest importance, since the development of the State is most closely connected with it. (2) The other point of view is the political-economic. The citizens of each one of these States became landowners soon after they had settled in Mesopotamia. They did not cultivate the land themselves, however, but the work was done by serfs or semi-serfs, obtained by military expeditions and by purchase. We have private contracts from which we see how boat expeditions were undertaken up the Euphrates against the northern provinces, where the less civilized tribes lived, and in which the contractors, who in this case were merchants and freebooters, undertook to procure slaves.

Among the Assyrians, in contrast to Babylonia, the idea of the State was one of somewhat firmer consolidation. This was caused by the situation of Assyria, wedged between Babylonia and northern Mesopotamia, and by the institution of a mercenary army since Tiglath-Pileser I, which was likewise an efficient factor in the formation of a stronger government than in Babylonia. Nevertheless, the political institutions of the two States are somewhat similar.

The officials were grouped in three orders—those who were occupied with the internal administration; those who watched over the neighboring and tributary States, and the military service that guarded the interests of the State against enemies, and were frequently employed as governors of subjugated States and tribes. The old nobility had, moreover, a direct interest in the State, inasmuch as they pre-eminently shared the offices among themselves.

The remaining subjects of the king were partly direct and partly indirect, and the latter certainly, in so far as they were, first of all, subordinate to the hierarchy of a temple.

The interest that the individual citizens had in the State lay, apart from the especial interests of the nobles, in the defense against outward attack and in the maintenance of law and justice; and we find, in fact, that the Babylonian State was characterized by a highly developed juridical life. As against the nomadic tribes the domestic militia and the mercenaries had to suffice more or less, while against the neighboring powers the tribes themselves were now and again impressed into service.

Of the constitution of the Babylonian State we know very little indeed, and the little we do know is of a negative character, only as the documents give us information of the abrogation of this or that privilege, etc. Besides that, there are preserved to us several charters from Babylonian provinces, which grant certain prerogatives to one family or

another. Thus it was legally established that officials of the State should not enter a free territory of this kind; that its inhabitants should not be arrested by the State police nor be constrained to the performance of a number of various villein services owed to the State. We may probably assume that certain cities obtained charters or franchises, but we have only proofs for the investure of foreigners with civic rights first in the time of the Persians, when very soon resounds the cry "*Civis Susanus sum*" (I am a citizen of Susa), which is important for our appreciation of Cyrus's statesmanship.

From all accounts we must conclude that the Babylonian kingdom was divided into provinces, which were subdivided into administrative districts, within which lay the free family estates. Everywhere but in the free estates or territories the central authority had the right to command arrests, to construct roads, bridges, etc., and to collect stallions for the breeding studs of the government, or to make arrangements for the maintenance of the studs. The contrast thus made apparent between the rights of the general government and those of the free estates indicates a period of transition from the feudal to the centralized system. The former is, of course, the earlier and bears witness to a time when the families were absolutely independent. With the growth of the central power, however, the importance and influence of the old families diminished, and only now and then occurred a relapse into the feudal system, such as, for instance, we learn from the charters. Such privileged territories were generally held in the possession of the old noble families. These also furnished the State with the entire force of its dignitaries, and the high political offices very often descended from father to son.

The citizens were, indeed, as explained above, very different as regards race and legal status, but soon became amalgamated under the influence of the higher civilization.

The Babylonians appear to us enterprising and rather vindictive and litigious, as shown by the numerous lawsuits. In their relations with the gods they assumed the position of equals, and yet at the same time displayed the deepest submission. They made offerings to the gods, but also demanded favors in return. If a person had once committed an offense, however, he could not lament sufficiently before the higher powers.

The family formed the focus of the whole life of the Babylonians, and presented a united and unbroken front. Thus we often find the interests of the State and those of the family in conflict. The sharp sep-

aration of the families from one another is easily explained by the former nomadic life of these peoples.

Since, moreover, the individuals of a clan were dependent upon one another, the legal conception was gradually developed that the property of an individual belonged not to himself, but to his whole family. We may thus explain the fact that real estate could be sold only on condition that the other members of the family gave their assent or signified their willingness by their presence while the bill of sale was being drawn up. A further important factor in the development of the family life is ancestor worship and the conceptions resulting from it, which have had the greatest influence in the religious development of the Semites.

The families are, then, as we have seen, the actual units out of which the State is composed. The individual members of the family stand, therefore, in a somewhat freer position as regards the State; they feel that they are first of all members of their own family, from which their connection with the State results secondarily.

The relation of the king to the subject was a double one. (1) The king was the highest representative of the family, which implies the conception of the whole State as one family. Under this conception he was the representative of his subjects in their relations with the gods, and had as such a great authority. (2) The king, however, did not belong to the particular families to which the individual subjects belonged. Therefore family interests in this regard often overbalanced the duty owed to the king.

The individual families in Babylon were often at enmity with one another, and this antagonism had close relations with external politics. All the powers round about Babylon, as the Elamites, Assyrians, and Kaldi, had their partisans in the city. The partisans, however, belonged respectively to the different families. According as the influence of this or that external power predominated in Babylon, one family was played off against another, and their relative possessions were thus shifted accordingly. The two boundary stones belonging to this period—one dated from Sargon, the other from Merodach-Baladan—are very good illustrations of this condition.

The relation of children to their parents was at first a rather patriarchal one, traces of which are found down to the latest times. We have a document from which appears the father's right of protest on the occasion of his son's intended marriage. The son might, indeed, marry against his father's will, but in that case the marriage was not

of full validity. On the other hand, we find phenomena which result from the further development of the family under the influence of private property rights. Documents dated from about 2300 B. C. refer to adoption to gain laborers. Another kind of adoption was one for the purpose of the fulfillment of obligations imposed by ancestor worship; that is to say, if there were no sons, a slave might be adopted, who should, after the father's death, bring him the customary offerings. We often see that elderly Babylonians intrusted themselves to a child or adopted slave for care and shelter, and made over their property to the child on condition of being supported by him. This custom is to be regarded already as a result of the evolution from collective to individual property rights.

We do not know much about Babylonian education. We can only draw inferences from what Assurbanipal relates concerning his education in the *bit riduti* (nursery). He states that he was trained in feats of bodily dexterity, and in reading and writing as well. We may probably assume that the well-to-do families had their children taught in a writing school (*bit dupsaruti*). We have fragments of tablets in which mention is made of a writing house, and there are still extant copies of historical and epic works prepared by writing pupils and then presented to a library.

Trades were diligently practiced, and children and slaves were bound apprentices to master craftsmen. The period of apprenticeship lasted several months or several years, according to the difficulty of the trade. This may have been the case among business men as well, for we find slaves who carried on business for their masters. If the slave proved to be true and clever, he might even be manumitted, but he still retained a connection with the family. Although then, in this case, the idea of the family did not rest upon blood relationship, it nevertheless appeared strong in all directions.

If, now, we compare the inference from the particulars gathered concerning the family with that drawn from the inscriptions, it is shown that what is apparent from the documents was also legally established. For example, sons-in-law could pass over into the family of the wife and become legally associated to the ancestor worship of this family.

As regards the relation of the family to the temple, we must make a distinction between the oldest cults existing within the domains of the individual families and the cults of entire cities. No especial imposts were necessary for the former, since these cults were cared for solely by the members of the respective families. For the latter, on the con-

trary, special taxes were raised by the king. Occasionally, however, it happened, also, that the king assigned to a temple a whole family, who then had to provide for its maintenance. This probably occurred for the most part after insurrections had been quelled.

In the deportations so often practiced by the Assyrians, the question is always of the noble families, who were thereby placed in a trying situation. They might, indeed, carry on their religious observances even at their place of exile, but were yet obliged to feel themselves in banishment, since, according to its idea, ancestor worship was attached to the graves of their forefathers. Upon the latter point we have but little material; nevertheless, this much is evident from it—that it was not necessary that the graves should be separate. We find, on the contrary, in Babylonia, great sepulchers, whither the dead from whole districts were brought. These sepulchers were naturally the centers for the surrounding district, and individual families connected themselves, respectively, with such a temple and such a sepulcher. To understand the development of the family upon the religious basis of ancestor worship is extremely important in the historical consideration of the Semitic nations, and without this understanding a number of facts cannot be explained.

The attempt has been made to prove the existence of a matriarchate also among the Semites, and it has been thought possible to adduce evidence for this view from the oldest inscriptions. This theory depends upon the arrangement of the names of the gods and goddesses and of the ideograms for man and woman. Nevertheless, the fact that in the Sumerian texts the feminine element precedes the masculine is capable of explanation on other grounds.

It appears, however, from the Old Babylonian documents that the wife could conclude independent private contracts; and that she had a legal standing in the family circle as well as before a court of law; that is, she was capable of being her own representative in regard to her own affairs. She had her private property and retained the right to dispose of it. Between the thirtieth and the twentieth centuries B. C. marriage had already developed in Babylonia upon the basis of individual property rights. Of course there existed at the same time remnants of more ancient modes of marriage, especially when the contracting parties were not of equal caste. Thus we have in the time of the New Babylonian Kingdom—that is, about the seventh century B. C. —a case where a man married a singer. In the marriage contract the death penalty was laid upon the eventual unfaithfulness of the wife; the

husband, on the other hand, could put his wife away forthwith on the payment to her of a specified sum of money. In ordinary cases the wife obtained her dowry back if she was repudiated. The children remained in the husband's family. There are, however, remnants of a system where, upon a separation, the daughters followed the mother. The material does not suffice to furnish answers to all questions relative to this subject.

We find women active in trade, industry, and agriculture, and although here, as elsewhere, men were in preponderance, we see them as priestesses in public worship. In the more ancient time they had not only the religious ceremonials to perform, but authority to manage the property of the deity. Women were also much esteemed as prohpetesses. Thus there was in Arbela a temple which harbored a great number of prophetesses who were, for example, much consulted by Asarhaddon.

After all that I have said about the position of woman there is no occasion for surprise if we find her in an influential position as queen. An indication of this is the short notice in the synchronistic history that an Assyrian princess ascended the Babylonian throne, and, *vice versa,* we find in the ninth century the Babylonian princess Samurammat upon the Assyrian throne. The latter had an important sovereign position. We find that she exercised influence upon the internal life of the State whose king she had married, and that she doubled Babylonian influence in Assyria. It is very probable that the legend of the Greeks concerning Semiramis can be traced back to the important position of Samurammat, to whose name, however, whole myths of the goddess Istar have been transferred. Reliefs from the time of Assurbanipal show that the position of the queen was an important one in this time, as well, and a similar conclusion concerning the position of the middle-class woman can be drawn from the documents. * * *

Among the slaves we must distinguish between (1) those that were in the private possession of an individual; (2) the *glebae adscripti,* villeins, who in part had arisen from the condition of slaves, in part had been reduced from the condition of freemen into serfdom; (3) the temple slaves, some of whom were purchased and some presented to the temple by pious citizens or by kings; (4) those belonging to the State, captives of war, of whom the greater part passed into the possession of individuals or of the temple. The first and third classes were employed in industries and about houses, the second in the cultivation of land.

We must consider industry in Babylon as highly developed. A

large number of certificates of delivery have come down to us, from which it appears (1) that private individuals in Babylonia possessed industrial establishments of the nature of factories, and (2) that the temples were great factories. The slaves were let out to work by their masters, and the hire either given to the slave, in case he himself delivered to his master the profit due from him as slave and maintained himself, or, on the other hand, given to the master if the latter provided for the slave's maintenance. Finally, the employer might give the slave his maintenance and the surplus earnings of the slave to the master. In this case the slave also received something for his labors. Thus the slave might accumulate a little capital. Besides, slavery was not as harsh in the Orient as in the Occident. The slave might buy his own freedom, and could be adopted and become a member of the family and rise to the highest places.

If one compares the employer's expenses when slaves were hired with the cost of free laborers, the latter are in most cases considerably more expensive. This appears to contradict an economic law that work under like conditions should receive equal compensation. I believe that I am able to solve the riddle in the following manner: If a free man entered into service, he had no claim for compensation if he became sick or disabled by his work. The slave, on the contrary, must be maintained by his master, and there were laws according to which whoever hired a slave was required to pay an indemnity to his master during the continuance of any disability incurred by the slave while a servant. Slaves were well protected by these exceedingly humane laws. Everyone who hired slaves belonging to others took good care not to disable them by overburdening their strength. As a consequence, the wages for a slave were smaller than those of a free man, who was obliged to forego indemnity if he received an injury from his work.

As for the *glebae adscripti,* they correspond to our tenants by villein service; they had to perform a kind of corvée, that is, they were obliged to work for the landowner on certain days. In most cases these slaves belonged to a temple, and on this account the temple had also jurisdiction over the slaves belonging to it. Fugitive and refractory slaves were put in chains, but might be released upon the guaranty of a comrade. Documents referring to such cases are extant.

Upon military matters in Babylon little has been handed down to us. The foreign rulers of the successive periods had their own national troops, and probably seldom drafted the Babylonians themselves into

military service. These troops gradually became property owners and Babylonians, which explains the clinging to the most ancient custom, namely, that the possession of landed property implied the obligation to furnish soldiers.

From the manner of the origin of the central powers, as sketched above, as well as from the idea that the country was subject to the gods, on the one side, and from the repeated political revolutions on the other, it results, as a matter of course, that out of the tribal possession of the land three forms of ownership must have developed: (1) Temple ownership; (2) State ownership, and (3) only secondarily, private ownership. All three forms are met in the New Babylonian documents, naturally with many variations.

Temple ownership developed out of the proprietary claim upon the whole territory comprised in the district about the temple. Originally a share of the products was yielded on this account to the deity and, therefore, to his temple. Naturally, in the evolution of things, conflicts of rights must have arisen, and thus, even in the oldest documents as yet in the Sumerian language, we see the kings engaged in regulating the temple revenues. Although gradually a partial conversion of the payments in kind into monetary payments took place, the former remained by far the most prevalent, even in the Babylon of Nebuchadnezzar and the Persians, as the contract tablets show. Since, especially in years of bad harvests and in times of war, the revenues established by the kings yielded but little, a fixed income was early provided, inasmuch as certain pieces of land were conveyed not merely into the theoretical proprietorship, but into the actual possession of the temple, in order that from them the expenses of the temple and the priests might be met.

For the form of State ownership we have only slight indications. If the Assyrian kings restored their possessions to the nobles exiled or imprisoned by the Kaldi, and, *vice versa,* the Kaldi kings did the same with regard to those exiled by the Assyrians, this restitution might have taken either the form of *enfeoffment,* of which we have an example in the Merodachbaladan stone of the Berlin Museum, or the form of *restitutio in integrum,* while it is yet impossible to determine certainly whether State or private ownership was really the form in question. So, in the case of a number of revenues, the question is still open whether we have before us taxes upon private property or rents on account of original State ownership. On the other hand a considerable number of documents in proof of genuine private ownership are extant.

If we consider the three forms of proprietorship from the point of view of revenues, it appears that the temples played a double rôle. If they only took a revenue from certain pieces of ground, they were upon the same footing as the State, which received revenues from the feudal estates, but if they held the estates in actual possession they were analogous to private individuals, who could manage these properties themselves or lease them.

We thus come to the subject of husbandry, which we may now divide into the two principal classes, management by the owner and farming on lease. I premise that this refers only to the property-holding classes. The agricultural laborers, that is, the real producers, were either slaves or peasants, who in their village community had gradually come to a certain condition of servitude, either to the temple or to the State or to the nobles. We have, then, to distinguish between the property-holding classes and the agricultural laborers. Naturally, a large number of modifications of condition arose which bridged over the transactions. But, in the rough, for the time which extends from the ascendancy of Assyria over Babylon to the downfall of the former power, that is, from 900 B. C. to about 600 B. C., one may assume as the greatest difference between the two neighboring States—a difference which was also characteristic of the different relation of power—the existence in Assyria of a free peasant class, in distinction to the existence in Babylonia of an unfree peasant class.

That the development of Assyria from a political point of view was much influenced by its social constitution is to be assumed as a matter of course. If, now, we can logically represent this development, we shall be able to judge of the social background, concerning which little documentary evidence remains. The test will be if the little furnished by the inscriptions agrees with the conception previously gained by us.

Now, it is quite easy to trace how the Assyrian kings gradually formed for themselves a military force suitable for rapid movements, and how the latter, originally, indeed, consisting of natives, became more and more a mercenary force recruited from the free lances of all Asia Minor. It is, moreover, clear from the history of Assur from the time of Asurnaçirpal on, that the internal tranquility was greater or less in proportion to the exhibition of power with regard to outside countries. This is explained by the fact that, so long as the surrounding peoples could be forced to pay tribute, the standing army was maintained by this tribute, but when from any cause tribute was less freely

given, the public burden fell more and more heavily upon the producing classes. When, under the kings of the eighth century, the north and east became less productive because of the pressing forward of Aryan tribes, circumstances must have come to such a pass that a complete revolution resulted, which brought Tiglath-Pileser III, and after him, Salmanassar IV, to the throne. Since this revolution took place in opposition to the ruling dynasty, and since neither king gave himself any trouble to establish his legitimacy by artificial pedigrees showing relationship to ancient legendary dynasties, it is probably to be assumed that they effected their usurpation in the face of the hitherto ruling classes of the military and priests by the help of a third factor. This, then, will also explain the fact that after the counter revolution of Sargon, he and his successors seized upon the old broken threads and relied chiefly upon the soldiery and priesthood. If, then, we inquire concerning this third factor, the only answer is that it is to be sought in the ranks of the townspeople and peasants. It is thus made possible to see in the revolution of 745 B. C. the victory of a revolt of peasants. And this, again, is only to be imagined on the hypothesis that in Assyria a strong peasant class unspoiled by servitude had survived. Always presupposing that development had taken place thus, the ascendancy of Assyria over the surrounding powers may be accounted for as the result of the liberated strength of the nation; and, moreover, the easy victory of Sargon, who accomplished the restoration with the aid of the priests, may be explained on the assumption that many years of warfare had shattered the social condition of the peasants.

There are two factors which make possible a verification of these facts. In the first place, the fact that Sargon, after he had seized the power, regulated property rights in favor of the temples, and, consequently, to the prejudice of the townsmen and peasants, who were probably reduced to yet more oppressive dependence. Thence it follows that, before the restoration, temple ownership had been restricted and relations with the temple relaxed, a fact which accordingly supports my representation of the development. And, secondly, the course of Sargon in the foundation of the city Dur-Sharrukin, inasmuch as he boasts that he has accomplished the expropriation of the landowners in a just manner, seems to indicate that a free peasant class had survived even after the restoration. Under the descendants of Sargon, the evolution of conditions probably tended more and more toward the extinction of this class, and thus formed the social groundwork which, after the downfall

of the dynasty, allowed Assyria as well as Babylon to become a Median and Persian province.

Farming on the owner's own account, as we know it from the temple records, was practiced in this manner: Peasants brought their products to the temple storehouses and received for these products receipts from officials appointed for this purpose. It was the same in the case of private owners. It seems, however, as if this kind of management was not very prevalent, or, at any rate, fell into disuse more and more in New Babylon. It was replaced by a system of leasing, which was highly perfected and formed the transition from domestic to commercial management.

I have already stated that the temples farmed out the collection of their revenues; likewise, as with private owners, they rented great tracts of land to contractors. These contractors made a business of renting, inasmuch as they either had the land cultivated on their own account by free or unfree laborers, or leased single pieces again. This sublease was concluded either after exactly the same form as between the first renter and the proprietor or else it was a share rent, so that the property did not give a fixed rent, but a proportionate return, which brought a larger or smaller sum according to the result of the harvest. Such farming on shares was also practiced where renters took property directly under their own management from proprietors. The picture of the economic relations of Babylon which we can thus sketch by the help of the contracts, resembles throughout that of Italy in recent centuries, whose political development, indeed, presents besides many striking analogies to that of Babylon. Fully to show this in detail, however, would lead me far beyond the limits of my essay.

Production was directed primarily toward the gaining of the necessaries of life. If the accounts of the Greeks had not already taught us this, the indigenous inscriptions would, immediately upon their decipherment, have shown that the main stress of social activity in Babylonia was placed upon a quite extraordinarily intensive cultivation of the soil. Innumerable are the receipts for the delivery of grain, of dates, of date litter, date wine, sesame, and garlic, which are found cited here, just as in the accounts of the Egyptian pyramids. And on this subject the accounts of the temples, of which the storehouses appeared to have ruled the market, speak more clearly than anything else. At the same time, the arrangement is especially peculiar, according to which live stock appears not to have been pastured upon the owner's land nor under the

owner's direction, but to have been given into the charge of contractors, who undertook to pasture the herds of various owners, engaged to guard and care for them, and were paid for their services. Here the influx of nomad tribes, with property consisting mainly of herds, and the resulting forms of collective ownership of large tracts of arable land, appears to have led very early to certain compromises with the perfected private ownership of real estate.

The consumption of these products, so far as they were not claimed by the producers themselves, must have taken place in the cities; and since exportation could probably have taken place only on a limited scale—for as far as Arabia the neighboring provinces seem to have produced their own grain—a conclusion as to the size of these cities is thereby justified. But then it is unavoidable to assume a highly flourishing condition of industry in these cities; and, indeed, the textile fabrics of Babylon must have been known and celebrated throughout the whole world of that time. The smith's and carver's arts had likewise attained a high degree of perfection. While, however, the materials for these arts—as metals, stone, and ivory—were not produced in the country, but entered it as objects of exchange for the products of Babylon, the material for weaving was in part obtained in the country. There are yet preserved for us many copies of orders by warrant, of which the temple workers received wool from the temple warehouses in order to make cloth of it; and this wool came not only from the possessions of the Babylonians themselves, but doubtless also from the flocks of the nomadic Aramæans, who became, by reason of having a market for their products, ever more firmly attached to the regions of the Euphrates and the Tigris through which they roamed. It is clear how there may and must have arisen through this development conditions which led to antagonism between plain and city, between pasture and agricultural country, and which were then reflected in the political intrigues according as individual parties represented one or the other interest. And it is clear, further, that with the peculiar growth of temple ownership—as I have developed it above out of the idea of proprietary claim upon the soil—antagonisms must have grown up between the priests or representatives of the interests of the temples and the kings as representatives of the interests of the State. Only by means of this insight into its material condition does the history of Babylon, at the time of the dynasty of Sargon, for instance, become intelligible.

I have already, above, emphasized the fact that the cultivation of

the land must have been a very intensive one. We see this from pictures which show how water was raised from canals onto the land by means of hydraulic machines; and we can draw this conclusion from the syllabaries published in the second volume of the London work of inscriptions, which deal with the various phases of agriculture. Finally we gather the same knowledge from the data of the lists which, drawn up by the temple officials, show what amount was to be raised in taxes alone from the several tracts of ground. These tracts themselves were distinguished according to the kind of cultivation; those where the clods were broken with the hoe were from this called *aggullattu*—that is, a tool which Tiglath-Pileser I, for example, had used on the construction of roadways in the Armenian highlands. Another kind of tool after which tracts of land were named was the *marru*, written *gish mar*—that is, the ideogram for wood, plus the ideogram *mar*, which is applied to a kind of wagon. Unfortunately the meaning of the word cannot yet be ascertained with precision. While *marru*, in the architectural inscription, is taken by some to mean scoop or bucket, others find in it the meaning wagon tongue. In some of the contracts *marru* certainly means a kind of vessel. It might not be impossible that there were two meanings in the word: (1) that of the vessel, which would then be referred to in the contracts, as well as in the architectural inscriptions; (2) also that of an implement which might perhaps find employment in transportation as well as in agriculture. I imagine it as a primitive kind of cart or dray, and consider it not impossible that by putting in a plowshare a plow might also have been made from it. Further, lands were designated as *zaqpu* to be derived from *zaqaf*, if they were planted with date palms, as *pi shulpi*, if bordering on water and swampy, as *ipinnu*, if watered with the water wheel, and as *taptu*, of which the exact signification as yet eludes definition. Especially in Babylonia the idea of fallow land appears to be lacking, which occurs quite frequently in the Assyrian contracts. Whether here the land actually was or could have been continuously cultivated, without fixed rotation and without pause, I leave undecided.

The individual tracts of land were not computed according to measurements of pure plane geometry, like building plots, but according to measures that had been evolved similar to the German *joch*, *morgen*, etc.—that is, according to the *gur*, or the real unit of capacity, which about corresponds to the German *wispel* (24 Berlin bushels). According to this, a piece of land was designated by the amount which could

be sowed upon it. Naturally, the ancient method must have been perfected under advanced conditions into a fixed measure of extent; it appears that generally a subdivision of the *gur*—namely, one-tenth of a *qa* (that is, one eighteen-hundredth of the *gur*), with the ideographic denotation *sha. hi. a*, of which I do not know the pronunciation—was fixed as a certain extent of land, which then passed as a unit of measure. It is not yet possible to say anything quite definite as to the size of this unit of measure; Oppert's calculation rests upon false premises. The celebrated assyriologist begins with the unit of linear measure, the ell, and is naturally compelled to construct besides the usual ell a much longer one for land measurement. I believe that I am able to come nearer the truth by a conjecture. If the ground area of a house is measured, it is done by the construction from the linear measure *gi*=*qanu*, (reed, *i. e.*, rod)=7 *u* (*u*=*ammatu*=an ell) of a unit of surface measure, namely, *gi. u*, that is, a surface of which one side was 7 ells, the other, 1 ell long. This construction was carried to such an extent that, if there were subdivisions, these were computed according to the surface unit *gi. shu. si, qanu, uban* (*bohen*) (*mehri haben*)=inch; the unit of measure was accordingly divided into parts, of which one side, equal to 7 ells, remained invariable, while the other side was one or more inches in length. It seems to me now, that the procedure was of like nature in the construction of the surface unit for agricultural land. Since *u* (=*ammatu*) is to be taken as a fundamental unit, according to the accounts of several documents, this ell of land will denote a piece of land, of which the short side was equal to 1 ell, while the long side, however, extended as far as was necessary in order that one *sha. hi. a* might be sowed upon it.

We do not learn very much about the real activity of the peasants. The ground was broken, watered after the sowing, guarded against injury from birds or herds, and the fences around the tracts kept in order. The duty of watching and putting the ditches in order is many times emphasized in the documents of lease. About the harvests and the manner of gathering them there is almost nothing to be gained from the inscriptions.

In the Babylon of Nebuchadnezzar II, the main harvest of grain was in Airu (the Hebrew Iyyar); for dates, in Arah-samma (the Hebrew Marheshwan). It is many times stipulated in the contracts that the grain or the dates to be delivered should be brought to the city by boat, and then delivered either into storehouses or granaries on the quay,

or in the house of the purchaser or of the lessor, respectively. That the waterways, which received careful attention, were used for this transportation, need not excite surprise. Since ship asses are many times mentioned, it might seem as though the boats had been drawn from the bank by asses, but that is probably not correct. According to the representations, rafts of the Assyrians were made of wooden frames, under which were fastened skins of rams, closed and water-tight, and filled with air. Navigation is practiced in similar manner down the river even to-day on the Tigris. At the place of destination the wood is sold along with the cargo, and the skins are piled up and transported back upon asses. Such asses might well be meant in the passages mentioned; nothing, however, is learned from this as to the manner of navigation on the canals.

The laborers had, as a remnant of the ancient domestic management, their full maintenance upon the land, and wages beside. If they were free peasants, these wages came from a share in the produce of the harvest. Slaves received their food and clothing from their masters, and if they were hired, the employers might give them wages as he did to free laborers; from this they paid to their owner the profit due him from a slave, but might, however, claim clothing from him. Therefore, there are also contracts of hire in which the employer pledged himself to furnish the clothing. It happened, besides, that the employer paid the slave's dues to the master, and guaranteed food and clothing, originally without paying the slave himself anything at all. This would seem to have been the earlier, the other the later form; yet nothing conclusive can as yet be established concerning these important questions.

From the part of the crop which now remained over, therefore, as follows from the conditions detailed above, the contractor's rent was to be paid, the owner's income, and the incumbent taxes and imposts. The rent was either a fixed rent or a share rent. In the first case there was fixed the amount of produce or money to be delivered to the owner. We have several such records, but unfortunately the particulars as to the amount of the rent permit of no inference as to its relation to the returns from the harvests. It was otherwise in the case of the share rents. There it was provided that, after deduction of costs, the proceeds were to be divided equally between tenant and owner. There are several statements in which, moreover, it was agreed who should pay the taxes.

The income of the owners of landed property, among whom the temples also are, of course, to be reckoned, came to them, according to

what was said above, in the shape of money or in that of produce. If the latter case prevailed, and this was the rule, there was, naturally, often a hardship for the owner in being compelled to meet his monetary obligations during a period of low prices for grain. On this account, we find an exceedingly large number of texts in which proprietors were forced to mortgage their lands in order to procure money. Nay, more, there even exists a document by which a Babylonian in straits mortgaged his harvest on the stalk.

The necessity of obtaining ready money arose not, perhaps, from private needs alone. The public institutions must many times have co-operated in this respect, as in Rome at the time of the Republic. For, although as already recounted at the outset, the temple imposts and even the direct State taxes were still usually delivered in the form of produce, and accordingly little was at first converted into fixed sums of money, there was another consideration which compelled the use of money. And this was the obligation which rested upon the individual estates to furnish soldiers and their equipment, and likewise to provide for their maintenance. This obligation was probably derived from conditions in which the landowner, as yet a peasant himself, held himself in readiness for service in arms in defense of the country. But, indeed, a mercenary soldiery must have developed in Babylon very early, especially because of the changing foreign rule.

Thus we find documents in which money is appropriated directly to serve for the equipment or maintenance of soldiers. Moreover, this explains the occurrence of the designation of *qashtu* for certain pieces of property; these were just such as had to furnish archers.

Other exactions, to mention these also which, indeed, did not demand a direct expenditure of money, resulted from the public works. For this the organs of administration could constrain the laborers of the temple estates as well as those of private ownership to a kind of corvée, in which their maintenance was furnished by the possessors of the estate.

In Babylon a very important industrial life had developed very early. Of raw products for this, the country had only clay, asphalt and reed in the best quality. All else, for instance, skins of animals, wool, so far as this was not furnished by the tribes which roamed through the country, had to be imported. On this account the kings were very often led to undertake military expeditions toward the Amanus, both in order to keep the way open for traffic and to obtain as tribute what they could

not buy. Babylon must, indeed, have been a gigantic thoroughfare for the trade between the Mediterranean and the Indian Ocean. About this we can learn nothing directly from the cuneiform inscriptions, though we can learn it indirectly, by inferences, and, moreover, from the Greek authors. One thing is nevertheless clear, that great amounts of raw products lay in the storehouses of Babylon.

Production was divided into the work of trades and that of factories. I call trades the activity of free or unfree laborers, because they were entitled to take apprentices and teach them their trade, an institution which fully corresponds to that of our modern trades. We have to look upon the temple and the industrial establishments of the rich citizens as factories. We have a number of certificates of delivery which show how the raw materials were delivered into the industrial establishments and how the finished products were delivered from them. These indicate how long the laborers worked and what amount of wages they received. As soon as the products of the trades came into demand as objects of luxury, craftsmanship touched the boundaries of art. The conditions in question are similar to those which existed in ancient Egypt. Artisanship is a refinement of what is commonly called trade work, which yet cannot attain individuality.

The fine arts were mainly employed upon the royal edifices. Almost every kind of technique was practiced there—metal work (especially embossed work), metal casting, ivory and wood carving, and stone and tile mosaic. The technical perfection of the last was especially remarkable. One is with reason astonished at the blues, partly metallic colors, partly *lapis lazuli,* which were burnt in upon the tiles for mosaics. The bronze doors of Balawat are a splendid relic of the artistic skill of former times. In considering the stone carving it is striking in how masterly a way the hardest stones were subdued in the most remote times, and that, too, with tools with which modern artists cannot work at all. At that time there was as yet no steel. Even the hard basalt was worked with chisels of tempered bronze. Among the minor arts, that of the lapidary is especially to be noticed. We find quite delightful engravings upon the hardest gems. Here, again, is such a technical perfection as could be developed only by the practice of centuries, and which later became lost, so that similar noticeable works could first be produced again only in Italian workshops. Wood carving was employed in the construction of thrones and of little Venus figures in wood. A similar highly developed art appears also in ivory work. Ivory was a much

prized article, for the sake of which the kings often undertook military expeditions, since the elephants were already exterminated on the Euphrates and the Tigris toward the beginning of the tenth century B. C. The ceramics, for which the most excellent raw material was present in all Babylonia, were also remarkable. The clay, which was already washed smooth by the rivers, was ground up so fine that clay writing tablets, for instance, were made of such superlative quality that they could be covered with writing so small as hardly to be read without a microscope.

The Babylonians are our predecessors in the art of printing. We have matrices in clay and in wood. The writing to be multiplied was first carved in wood, then cast in clay, and could then be imprinted upon any number of clay tablets.

A highly developed branch of industry was the art of weaving and embroidery, although we have no specimen of the material. We can form an idea of this art from the representations of the Egyptians and the Babylonians. The Babylonians understood how to weave very thin fabrics as well as the thickest. I myself have seen a clay tablet in London which had been laid upon a piece of linen, so that even now the position of the threads and the excellence of the fabric to which they belonged can be estimated.

The tanner's trade, moreover, was highly developed. This, too, can be judged of only through pictorial representations. According to these, shoes and the harness and saddles of horses were elaborately worked.

Those who carried on industry were partly free, partly slaves; the former received wages, the latter were hired or rented. The owners of the slaves received from the latter, if they were skilled laborers, a fixed income. This must be clearly recognized in the picture of the social relations in Babylon. It is a matter of course, that here the interests of the owners and those of the laborers must have been diverse, and that, in spite of the immense population of Babylon, its political conditions must have been very unstable, because only the rich—that is, the dwindling minority—had an interest in the maintenance of order. Babylon had never been able to attain the position of Rome, where the Plebs constantly obtained more rights.

As for the instruments of labor in Old Babylon, they were not highly developed. On the other hand, a high degree of technical perfection was wrought out with these poor instruments. Among us the

reverse is the case. The tools are very good, but the skill of the human hand has greatly diminished. Whether a division of labor in the modern sense existed in Babylon cannot be yet made clear. There are, nevertheless, a number of facts which would point to it.

According to the representations in the reliefs, the citizens attended public gatherings on state occasions and temple ceremonies, richly adorned and with the insignia which distinguished them as citizens; that is, in flowing garments, with large and artistically made head-dresses, with a seal ring upon the finger, with staff in hand, with girdle and beautifully embroidered leather shoes. In everyday work, on the contrary, we see the same citizens carrying on their business in shirt and apron. Unfortunately, the remains which are at hand come mostly from temples and palaces, and therefore we can form a clear picture only of great state functions.

Several scholars maintain that in Babylon only the temples and palaces are to be considered as great buildings, while the inhabitants lived in primitive huts. This is an untenable view. Portions of foundation walls which belonged to private houses have been discovered, and we are justified in the assumption that Babylon, so long as it existed, made, with its houses, the impression of a great city. One must not forget, withal, that it was an oriental city which required another kind of architecture than that of our great cities. Upon the main streets, which were paved with stone, little outbuildings, such as we still see in oriental cities, which must have served as booths or bazaars, were erected before the houses. There, as in the gates of the temples and palaces, handiwork and traffic were briskly carried on.

Money, the medium of exchange, received its first and best improvement there. It had passed from the conception of barter to the refined conception of value. In even earlier times gold and silver money, and also as subsidiary coinage, copper, bronze, and iron were used. The further the development went the more need there must have been of having the metals in a fixed form and in certain proportions of weight in order that there might be no necessity for weighing the metals each time. It was therefore molded into bars and rings. Unfortunately, no such coins have been preserved, but we have written references to them. The unit of value was the *mine*. This contained 60 *sheqels*, and the latter had again subdivisions, but these varied. From the two first developments of money arises the third; the use of money as capital; that is, interest-bearing capital. We have, in about 2300 B. C., the

transition, as people pledged themselves to work a certain length of time for a sum of money which they must return later.

Exchange was known in Babylon, and there are statements of the changes in value of money. Moreover, the ratio of value between gold and silver was fixed.

This fine development of the relations of value was accompanied by another—the relation of the purchasing power of money to livelihood. A number of documents exist which show that the living expenses of the laborers cannot have been very high, and this agrees with what we know of the Orient from other sources. The soil furnishes the necessaries of life without man's having to take much trouble. Consequently, idleness and beggary are nowhere more widespread than in the Orient. Nowhere is industry urged forward in a more brutal way. There are many reliefs from Babylon and Egypt which show laborers constantly driven by blows from a stick; during the transportation of colossal weights an overseer with a club stands behind every three or four laborers.

CONCLUSION

During the correction of the preceding sketch, which the editor of the Mittheilungen has sent to the press half against my will, but which I will not now withdraw, since otherwise I should be obliged to let it lie for many years to come without finding the time to work it over thoroughly, two gaps came to my special notice, the filling up of which, however, is subsequently to take place elsewhere. The professional position of the priests will probably be described by Zimmern in his contributions to the knowledge of the Babylonian religion; that of the judges will be treated by Kohler in the fourth part of the work published by Kohler and myself upon Babylonian juridical life.

Translated from Mitteilungen der Vorderasiatischen Gesellschaft, Berlin, 1896.

PHYSICS

The most important advances in theoretical Physics during the last thirty years have been connected with the consideration of waves in the ether. In 1873 and even before, J. Clerk Maxwell developed his theory that electricity like light is a wave in the ether. The main proof of this theory rested upon the fact that it could be made to account for electrical phenomena and that the speed of light and electricity seemed to be approximately the same. In 1888 Hertz of Germany succeeded in actually detecting waves in electricity by the method described below. The gradually acquired knowledge of their production and control have resulted in the wireless telegraph, the details of which are given under this head.

The discovery of Crookes' rays and of the X-rays by Röntgen points the way to a knowledge of new forms of radiation.

JAMES CLERK MAXWELL

James Clerk Maxwell was born in 1831. He attended Edinburgh from 1847 to 1850, then entered Cambridge and was graduated in 1854, taking the honor of second wrangler.

From 1856 to 1860 he taught in Marichal College, Aberdeen, and from 1860 to 1868 in King's College, London.

He was a mathematician at fifteen, and several of his papers were read before the Royal Society of Edinburgh before he was nineteen. In 1867 he took up the question of electricity and strove to find a theory of it which would not include such a conception as action from a distance. This developed into the theory that electricity is a condition of stress or strain in the ether, in other words, that it is a wave in the same medium as light and travels at the same rate of speed. Hertz's experiments in 1888 have done much to confirm this theory, and such inventions as wireless telegraphy are a direct result.

Maxwell died in 1879.

ELECTRICITY A WAVE IN THE ETHER

In several parts of this treatise an attempt has been made to explain electromagnetic phenomena by means of mechanical action transmitted from one body to another by means of a medium occupying the space between them. The undulatory theory of light also assumes the existence of a medium. We have now to show that the properties of the electromagnetic medium are identical with those of the luminiferous medium.

To fill all space with a new medium whenever any new phenomenon is to be explained is by no means philosophical, but if the study of two different branches of science has independently suggested the idea of a medium, and if the properties which must be attributed to the medium in order to account for electromagnetic phenomena are of the same kind as those which we attribute to the luminiferous medium in order to account for the phenomena of light, the evidence for the physical existence of the medium will be considerably strengthened.

But the properties of bodies are capable of quantitative measurement. We therefore obtain the numerical value of some property of the medium, such as the velocity with which a disturbance is propagated through it, which can be calculated from electromagnetic experiments, and also observed directly in the case of light. If it should be found that the velocity of propagation of electromagnetic disturbances is the same as the velocity of light, and this not only in air, but in other transparent media, we shall have strong reasons for believing that light is an electromagnetic phenomenon, and the combination of the optical with the electrical evidence will produce a conviction of the reality of the

medium similar to that which we obtain, in the case of other kinds of matter, from the combined evidence of the senses.

When light is emitted, a certain amount of energy is expended by the luminous body, and if the light is absorbed by another body, this body becomes heated, showing that it has received energy from without. During the interval of time after the light left the first body and before it reached the second, it must have existed as energy in the intervening space.

According to the theory of emission, the transmission of energy is effected by the actual transference of light-corpuscules from the luminous to the illuminated body, carrying with them their kinetic energy, together with any other kind of energy of which they may be the receptacles.

According to the theory of undulation, there is a material medium which fills the space between the two bodies, and it is by the action of contiguous parts of this medium that the energy is passed on, from one portion to the next, until it reaches the illuminated body.

The luminiferous medium is therefore, during the passage of light through it, a receptacle of energy. In the undulatory theory, as developed by Huygens, Fresnel, Young, Green, etc., this energy is supposed to be partly potential and partly kinetic. The potential energy is supposed to be due to the distortion of the elementary portions of the medium. We must therefore regard the medium as elastic. The kinetic energy is supposed to be due to the vibratory motion of the medium. We must therefore regard the medium as having a finite density.

In the theory of electricity and magnetism adopted in this treatise, two forms of energy are recognised, the electrostatic and the electrokinetic, and these are supposed to have their seat, not merely in the electrified or magnetized bodies, but in every part of the surrounding space, where electric or magnetic force is observed to act. Hence our theory agrees with the undulatory theory in assuming the existence of a medium which is capable of becoming a receptacle of two forms of energy.

Let us next determine the conditions of the propagation of an electromagnetic disturbance through a uniform medium, which we shall suppose to be at rest, that is, to have no motion except that which may be involved in electromagnetic disturbances.

Let C be the specific conductivity of the medium, K its specific capacity for electrostatic induction, and u its magnetic "permeability."

The quantity V, in Art. 784, which expresses the velocity of propagation of electromagnetic disturbances in a non-conducting medium is, by equation (10), equal to $\frac{1}{\sqrt{Ku}}$.

If the medium is air, and if we adopt the electrostatic system of measurement, $K=1$ and $u=\frac{1}{v^2}$, so that $V=v$, or the velocity of propagation is numerically equal to the number of electrostatic units of electricity in one electromagnetic unit. If we adopt the electromagnetic system, $K=\frac{1}{v^2}$ and $u=1$, so that the equation $V=v$ is still true.

On the theory that light is an electromagnetic disturbance, propagated in the same medium through which other electromagnetic actions are transmitted, V must be the velocity of light, a quantity the value of which has been estimated by several methods. On the other hand, v is the number of electrostatic units of electricity in one electromagnetic unit, and the methods of determining this quantity have been described in the last chapter. [Here inserted.]

Comparison of Units of Electricity

[Since the ratio of the electromagnetic to the electrostatic unit of electricity is represented by a velocity, we shall in future denote it by the symbol v. The first numerical determination of this velocity was made by Weber and Kohlrausch.

Their method was founded on the measurement of the same quantity of electricity, first in electrostatic and then in electromagnetic measure.

The quantity of electricity measured was the charge of a Leyden jar. It was measured in electrostatic measure as the product of the capacity of the jar into the difference of potential of its coatings. The capacity of the jar was determined by comparison with that of a sphere suspended in an open space at a distance from other bodies. The capacity of such a sphere is expressed in electrostatic measure by its radius. Thus the capacity of the jar may be found and expressed as a certain length. See Art. 227.

The difference of the potentials of the coatings of the jar was measured by connecting the coatings with the electrodes of an electrometer,

the constants of which were carefully determined, so that the difference of the potentials, E, became known in electrostatic measure.

By multiplying this by c, the capacity of the jar, the charge of the jar was expressed in electrostatic measure.

To determine the value of the charge in electromagnetic measure, the jar was discharged through the coil of a galvanometer. The effect of the transient current on the magnet of the galvanometer communicated to the magnet a certain angular velocity. The magnet then swung round to a certain deviation, at which its velocity was entirely destroyed by the opposing action of the earth's magnetism.

By observing the extreme deviation of the magnet the quantity of electricity in the discharge may be determined in electromagnetic measure, as in Art. 748, by the formula

$$Q = \frac{H}{G} \frac{T}{\pi} 2 \sin \tfrac{1}{2} \theta,$$

where Q is the quantity of electricity in electromagnetic measure. We have therefore to determine the following quantities:

H, the intensity of the horizontal component of terrestrial magnetism; see Art. 456.

G, the principal constant of the galvanometer; see Art. 700.

T, the time of a single vibration of the magnet; and

θ, the deviation due to the transient current.

The value of v obtained by MM. Weber and Kohlrausch was

$$v = 310740000 \text{ metres per second.}$$

The property of solid dielectrics, to which the name of Electric Absorption has been given, renders it difficult to estimate correctly the capacity of a Leyden jar. The apparent capacity varies according to the time which elapses between the charging or discharging of the jar and the measurement of the potential, and the longer the time the greater is the value obtained for the capacity of the jar.

Hence, since the time occupied in obtaining a reading of the electrometer is large in comparison with the time during which the discharge through the galvanometer takes place, it is probable that the estimate of the discharge in electrostatic measure is too high, and the value of v, derived from it, is probably also too high.]

They are quite independent of the methods of finding the velocity of light. Hence the agreement or disagreement of the values of V and of v furnishes a test of the electromagnetic theory of light.

In the following table, the principal results of direct observation of the velocity of light, either through the air or through the planetary spaces, are compared with the principal results of the comparison of the electric units:—

Velocity of Light (metres per second).		Ratio of Electric Units (metres per second).	
Fizeau	314000000	Weber	310740000
Aberration, etc., and Sun's Parallax	308000000	Maxwell	288000000
Foucault	298360000	Thomson	282000000

It is manifest that the velocity of light and the ratio of the units are quantities of the same order of magnitude. Neither of them can be said to be determined as yet with such a degree of accuracy as to enable us to assert that the one is greater or less than the other. It is to be hoped that, by further experiment, the relation between the magnitudes of the two quantities may be more accurately determined.

In the meantime our theory, which asserts that these two quantities are equal, and assigns a physical reason for this equality, is certainly not contradicted by the comparisons of these results such as they are.

In the following table, taken from a paper by E. B. Rosa, *Phil. Mag.* 28, p. 315, 1889, the determinations of 'v' corrected for the error in the B. A. unit are given:—

1856	Weber and Kohlrausch	3.107×10^{10} (cm. per second)
1868	Maxwell	2.842×10^{10}
1869	W. Thomson and King	2.808×10^{10}
1872	McKichan	2.896×10^{10}
1879	Ayrton and Perry	2.960×10^{10}
1880	Shida	2.955×10^{10}
1883	J. J. Thomson	2.963×10^{10}
1884	Klemencic	3.019×10^{10}
1888	Himstedt	3.009×10^{10}
1889	W. Thomson	3.004×10^{10}
1889	E. B. Rosa	2.9993×10^{10}
1890	J. J. Thomson and Searle	2.9955×10^{10}

VELOCITY OF LIGHT IN AIR.

Cornu (1878)	3.003×10^{10}
Michelson (1879)	2.9982×10^{10}
Michelson (1882)	2.9976×10^{10}
Newcomb (1885)	$\left\{\begin{matrix} 2.99615 \\ 2.99682 \\ 2.99766 \end{matrix}\right\} \times 10^{10}$

In other media than air, the velocity V is inversely proportional to the square root of the product of the dielectric and the magnetic inductive capacities. According to the undulatory theory, the velocity of light in different media is inversely proportional to their indices of refraction.

There are no transparent media for which the magnetic capacity differs from that of air more than by a very small fraction. Hence the principal part of the difference between these media must depend on

their dielectric capacity. According to our theory, therefore, the dielectric capacity of a transparent medium should be equal to the square of its index of refraction.

But the value of the index of refraction is different for light of different kinds, being greater for light of more rapid vibrations. We must therefore select the index of refraction which corresponds to waves of the longest periods, because these are the only waves whose motion can be compared with the slow processes by which we determine the capacity of the dielectric.

The only dielectric of which the capacity has been hitherto determined with sufficient accuracy is paraffin, for which in the solid form MM. Gibson and Barclay found.

$$K = 1.975.$$

Dr. Gladstone has found the following values of the index of refraction of melted paraffin, sp. g. 0.779, for the lines A, D and H:—

Temperature	A	D	H
54°C	1.4306	1.4357	1.4499
57°C	1.4294	1.4343	1.4493

from which I find that the index of refraction for waves of infinite length would be about 1.422.

The square root of K is 1.405.

The difference between these numbers is greater than can be accounted for by errors of observation, and shows that our theories of the structure of bodies must be much improved before we can deduce their optical from their electrical properties. At the same time, I think that the agreement of the numbers is such that if no greater discrepancy were found between the numbers derived from the optical and the electrical properties of a considerable number of substances, we should be warranted in concluding that the square root of K, though it may not be the complete expression for the index of refraction, is at least the most important term in it.

M. HENRI POINCARE

THE MAXWELL AND HERTZ THEORY OF ELECTRICITY AND LIGHT

It was at the moment when the experiments of Fresnel were forcing the scientific world to admit that light consists of the vibrations of a highly attentuated fluid filling interplanetary spaces that the researches of Ampère were making known the laws of the mutual action of currents and were so enunciating the fundamental principles of electrodynamics.

It needed but one step to the supposition that that same fluid, the ether, which is the medium of luminous phenomena, is at the same time the vehicle of electrical action. In imagination Ampère made this stride; but the illustrious physicist could not foresee that the seducing hypothesis with which he was toying, a mere dream for him, was ere long to take a precise form and become one of the vital concerns of exact science.

A dream it remained for many years, till one day, after electrical measurements had become extremely exact, some physicist, turning over the numerical data, much as a resting pedestrian might idly turn over a stone, brought to light an odd coincidence. It was that the factor of transformation between the system of electro-statical units and the system of electro-dynamical units was equal to the velocity of light. Soon the observations directed to this strange coincidence became so exact that no sane head could longer hold it a mere coincidence. No longer could it be doubted that some occult affinity existed between optical and electrical phenomena. Perhaps, however, we might be wondering to this day what this affinity could be were it not for the genius of Clerk Maxwell.

Displacement Currents

The reader is aware that solid bodies are divided into two classes, conductors through which electricity can move in the form of a galvanic current, and nonconductors, or dielectrics. The electricians of former

days regarded dielectrics as quite inert, having no part to play but that of obstinately refusing passage to electricity. Had that been so, any one nonconductor might be replaced by any other without making any difference in the phenomena; but Faraday found that that was not the case. Two condensers of the same form and dimensions put into connection with the same source of electricity do not take the same charge, though the thickness of the isolating plate be the same, unless the matter of that plate be chemically the same. Now Clerk Maxwell had too deeply studied the researches of Faraday not to comprehend the importance of dielectrics and the imperative obligation to recognize their active part.

Besides, if light is but an electric phenomenon, when it traverses a thickness of glass electrical events must take place in that glass. And what can be the nature of those events? Maxwell boldly answers, they are, and must be, currents.

All the experience of his day seemed to contradict this. Never had currents been observed except in conductors. How was Maxwell to reconcile his audacious hypothesis with a fact so well established as that? Why is it that under certain circumstances those supposed currents produce manifest effects, while under ordinary conditions they can not be observed at all.

The answer was that dielectrics resist the passage of electricity not so much more than conductors do, but in a different manner. Maxwell's idea will best be understood by a comparison.

If we bend a spring, we meet a resistance which increases the more the spring is bended. So, if we can only dispose of a finite force, a moment will come when the motion will cease, equilibrium being reached. Finally, when the force ceases the spring will in flying back restore the whole of the energy which has been expended in bending it.

Suppose, on the other hand, that we wish to displace a body plunged into water. Here again a resistance will be experienced, but it will not go on increasing in proportion as the body advances, supposing it to be maintained at a constant velocity. So long as the motive force acts, equilibrium will never, then, be attained; nor when the force is removed will the body in the least tend to return, nor can any portion of the energy expended be restored. It will, in fact, have been converted into heat by the viscosity of the water.

The contrast is plain; and we ought to distinguish elastic resistance from viscous resistance. Using these terms, we may express Maxwell's

idea by saying that dielectrics offer an elastic resistance, conductors a viscous resistance, to the movements of electricity. Hence, there are two kinds of currents; currents of displacement which traverse dielectrics and ordinary currents of conduction which circulate in conductors.

Currents of the first kind, having to overcome an elastic resistance which continually increases, naturally can last but a very short time, since a state of equilibrium will quickly be reached.

Currents of conduction, on the other hand, having only a viscous resistance to overcome, must continue so long as there is any electromotive force.

Let us return to the simile used by M. Cornu in his notice in the Annuaire du Bureau des Longitudes for 1893. Suppose we have in a reservoir water under pressure. Lead a tube plumb downward into the reservoir. The water will rise in the tube, but the rise will stop when hydrostatic equilibrium is attained—that is, when the downward pressure of the water in the tube above the point of application of the first pressure on the reservoir, and due to the weight of the water, balances that first pressure. If the pipe is large, there will be no friction or loss of head, and the water so raised can be used to do work. That represents a current of displacement.

If, on the other hand, the water flows out of the reservoir by a horizontal pipe, the motion will go on till the reservoir is emptied; but if the tube is small and long there will be a great loss of energy and considerable production of heat by friction. That represents a current of conduction.

Though it would be vain, not to say idle, to attempt to represent all details, it may be said that everything happens just as if the currents of displacement were acting to bend a multitude of little springs. When the currents cease, electrostatic equilibrium is established, and the springs are bent the more, the more intense is the electric field. The accumulated work of the springs—that is, the electrostatic energy—can be entirely restored as soon as they can unbend, and so it is that we obtain mechanical work when we leave the conductors to obey the electrostatic attractions. Those attractions must be due to the pressure exercised on the conductors by the bent springs. Finally, to pursue the image to the death, the disruptive discharge may be compared to the breaking of the springs when they are bent too much.

On the other hand, the energy employed to produce conduction currents is lost, being wholly converted into heat, like that spent in over-

coming the viscosity of fluids. Hence it is that the conducting wires become heated.

From Maxwell's point of view it seems that all currents are in closed circuits. The older electricians did not so opine. They regarded the current circulating in a wire joining the two poles of a pile as closed; but if in place of directly uniting the two poles we place them in communication with the two armatures of a condenser, the momentary current which lasts while the condenser is getting charged was not considered as a current round a closed circuit. It went, they thought, from one armature through the wire, the battery, the other wire, to the other armature, and there it stopped. Maxwell, on the contrary, supposed that in the form of a current of displacement it passes through the nonconducting plate of the condenser, and that precisely what brings it to cessation is the opposite electromotive force set up by the displacement of electricity in this dielectric.

Currents become sensible in three ways—by their heating effects, by their actions on other currents and on magnets, and by the induced currents to which they give rise. We have seen why currents of conduction develop heat and why currents of displacement do not. But Maxwell's hypothetical currents ought at any rate to produce electromagnetic and inductive effects. Why do these effects not appear? The answer is, that it is because a current of displacement can not last long enough. That is to say, they can not last long in one direction. Consequently in a dielectric no current can long exist without alternation. But the effects ought to and will become observable if the current is continually reversed at sufficiently short intervals.

The Nature of Light

Such, according to Maxwell, is the origin of light. A luminiferous wave is a series of alternating currents produced in dielectrics, in air, or even in the interplanetary void, and reversed in direction a million of million of times per second. The enormous induction due to these frequent alternations sets up other currents in the neighboring parts of the dielectric, and so the waves are propagated.

Calculation shows that the velocity of propagation would be equal to the ratio of the units, which we know is the velocity of light.

Those alternative currents are a sort of electrical oscillation. Are they longitudinal, like those of sound, or are they transversal, like those of Fresnel's ether? In the case of sound the air undergoes alternative condensations and rarefactions. The ether of Fresnel, on the other

hand, behaves as if it were composed of incompressible layers capable only of slipping over one another. Were these currents in open paths, the electricity carried from one end to the other would become accumulated at one extremity. It would thus be condensed and rarefied like air, and its vibrations would be longitudinal. But Maxwell only admits currents in closed circuits; accumulation is impossible, and electricity behaves like the incompressible ether of Fresnel, with its transversal vibrations.

Experimental Verification

We thus obtain all the results of the theory of waves. Yet this was not enough to decide the physicists to adopt the ideas of Maxwell. It was a seductive hypothesis; but physicists consider hypotheses which lead to no distinct observational consequences as beyond the borders of their province. That province, so defined, no experimental confirmation of Maxwell's theory invaded for twenty-five years.

What was wanted was some issue between the two theories not too delicate for our coarse methods of observation to decide. There was but one line of research along which any *experimentum crucis* was to be met with.

The old electro-dynamics makes electro-magnetic induction take place instantaneously; but according to Maxwell's doctrine it propagates itself with the velocity of light.

The point was then to measure, or at least to make certain, a velocity of propagation of inductive effects. This is what the illustrious German physicist Hertz has done by the method of interferences.

The method is well known in its application to optical phenomena. Two luminous rays from one identical center interfere when they reach the same point after pursuing paths of different lengths. If the difference is one, two, or any whole number of wave lengths, the two lights re-enforce one another so that if their intensities are equal, that of their combination is four times as great. But if the difference is an odd number of half wave lengths, the two lights extinguish one another.

Luminiferous waves are not peculiar in showing this phenomenon; it belongs to every periodic change which is propagated with definite velocity. Sound interferes just as light does, and so must electro-dynamic induction if it is strictly periodic and has a definite velocity of propagation. But if the propagation is instantaneous there can be no interference, since in that case there is no finite wave length.

The phenomenon, however, could not be observed were the wave length greater than the distance within which induction is sensible. It is therefore requisite to make the period of alternation as short as possible.

Electrical Exciters

We can obtain such currents by means of an apparatus which constitutes a veritable electrical pendulum. Let two conductors be united by a wire. If they have not the same electric potential the electrical equilibrium is disturbed and tends to restore itself, just as the molar equilibrium is disturbed when a pendulum is carried away from the position of repose.

A current is set up in the wire, tending to equalize the potential, just as the pendulum begins to move so as to be carried back to the position of repose. But the pendulum does not stop when it reaches that position. Its inertia carries it farther. Nor, when the two electrical conductors reach the same potential, does the current in the wire cease. The equilibrium instantaneously existing is at once destroyed by a cause analogous to inertia, namely self-induction. We know that when a current is interrupted it gives rise in parallel wires to an induced current in the same direction. The same effect is produced in the circuit itself, if that is not broken. In other words, a current will persist after the cessation of its causes, just as a moving body does not stop the instant it is no longer driven forward.

When, then, the two potentials become equal, the current will go on and give the two conductors relative charges opposite to those they had at first. In this case, as in that of the pendulum, the position of equilibrium is passed, and a return motion is inevitable. Equilibrium, again instantaneously attained, is at once again broken for the same reason; and so the oscillations pursue one another unceasingly.

Calculation shows that the period depends on the capacity of the conductors in such a way that it is only necessary to diminish that capacity sufficiently (which is easily done) to have an electric pendulum capable of producing an alternating current of extremely short period.

All that was well enough known by the theoretical researches of Lord Kelvin and by the experimentation of Federson on the oscillatory discharge of the Leyden jar. It was not that which constituted the originality of Hertz.

But it is not enough to construct a pendulum; it is further requisite to set it into oscillation. For that, it is necessary to carry it off from equilibrium and to let it go suddenly, that is to say, to release it in a time short as compared to the period of its oscillation.

For if, having pulled a pendulum to one side by a string, we were to let go of the string more slowly that the pendulum would have descended of itself, it would reach the vertical without momentum, and no oscillation would be set up.

In like manner, with an electric pendulum whose natural period is, say, a hundred-millionth of a second, no mechanical mode of release would answer the purpose at all, sudden as it might seem to us with our more than sluggish conceptions of promptitude. How, then, did Hertz solve the problem?

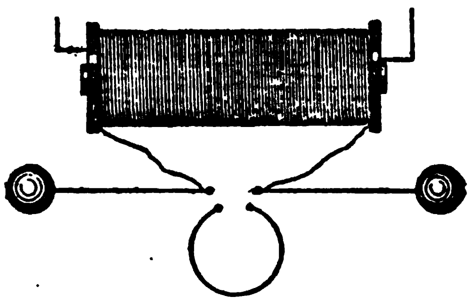

FIG. 1. The Hertz Exciter.

To return to our electric pendulum, a gap of a few millimeters is made in the wire which joins the two conductors. This gap divides our apparatus into two symmetrical parts, which are connected to the two poles of a Ruhmkorff coil. The induced current begins to charge the two conductors, and the difference of their potential increases with relative slowness.

At first the gap prevents a discharge from the conductors; the air in it plays the rôle of insulator and maintains our pendulum in a position diverted from that of equilibrium.

But when the difference of potential becomes great enough, a spark will jump across. If the self-induction is great enough and the capacity and resistance small enough, there will be an oscillatory discharge whose period can be brought down to a hundred-millionth of a second.

The oscillatory discharge would not, it is true, last long by itself; but it is kept up by the Ruhmkorff coil, whose current is itself oscillatory with a period of about a hundred-thousandth of a second, and thus the pendulum gets a new impulse as often as that.

The instrument just described is called a resonance exciter. It produces oscillations which are reversed from a hundred million to a thousand million times per second. Thanks to this extreme frequency, they can produce inductive effects at great distances. To make these effects sensible another electric pendulum is used, called a resonator. In this the coil is suppressed. It consists simply of two little metallic spheres very near to one another, with a long wire connecting them in a roundabout way.

The induction due to the exciter will set the reasonator in vibration the more intensely the more nearly the natural periods of vibration are the same. At certain phases of the vibration the difference of potential of the two spheres will be just great enough to cause the sparks to leap across.

Production of the Interferences

Thus we have an instrument which reveals the inductive waves which radiate from the exciter. We can study them in two ways. We may either expose the resonator to the direct induction of the exciter at a great distance, or else make this induction act at a small distance on a long conducting wire which the electric wave will follow and which in its turn will act at a small distance on the resonator.

Whether the wave is propagated along a wire or across the air, interferences can be produced by reflection. In the first case it will be reflected at the extremity of the wire, which it will again pass through in the opposite direction. In the second case it can be reflected on a metallic leaf which will act as a mirror. In either case the reflected ray will interfere with the direct ray, and positions will be found in which the spark of the resonator will be extinguished.

Experiments with a long wire are the easier and furnish much valuable information, but they cannot furnish an *experimentum crucis,* since in the old theory, as in the new, the velocity of the electric wave in a wire should be equal to that of light. But experiments on direct induction at great distances are decisive. They not only show that the velocity of propagation of induction across air is finite, but also that it is equal to the velocity of the wave propagated along a wire, conformably to the ideas of Maxwell.

Synthesis of Light

I shall insist less on other experiments of Hertz, more brilliant but less instructive. Concentrating with a parabolic mirror the wave of induction that emanates from the exciter, the German physicist obtained a true pencil of rays of electric force, susceptible of regular reflection and refraction. These rays, were the period but one-millionth of what it is, would not differ from rays of light. We know that the sun sends us several varieties of radiations, some luminiferous, since they act on the retina, others dark, infra-red, or ultra-violet, which reveal themselves in chemical and calorific effects. The first owe the qualities which render them sensible to us to a physiological chance. For the physicist, the infra-red differs from red only as red differs from green; it simply has a greater wave length. That of the Hertzian radiations is far greater still, but they are mere differences of degree, and if the ideas of Clerk Maxwell are true, the illustrious professor of Bonn has effected a genuine synthesis of light.

Conclusion

Nevertheless, our admiration for such unhoped-for successes must not let us forget what remains to be accomplished. Let us endeavor to take exact account of the results definitely acquired.

In the first place, the velocity of direct induction through air is finite; for otherwise interferences could not exist. Thus the old electrodynamics is condemned. But what is to be set up in its place? Is it to be the doctrine of Maxwell, or rather some approximation to that, for it would be too much to suppose that he had foreseen the truth in all its details? Though the probabilities are accumulating, no complete demonstration of that doctrine has ever attained.

We can measure the wave length of the Hertzian oscillations. That length is the product of the period into the velocity of propagation. We should know the velocity if we knew the period; but this last is so minute that we cannot measure it; we can only calculate it by a formula due to Lord Kelvin. That calculation leads to figures agreeable to the theory of Maxwell; but the last doubts will only be dissipated when the velocity of propagation has been directly measured. (See Note I.)

But this is not all. Matters are far from being as simple as this brief account of the matter would lead one to think. There are various complications.

In the first place, there is around the exciter a true radiation of

induction. The energy of the apparatus radiates abroad, and if no source feeds it, it quickly dissipates itself and the oscillations are rapidly extinguished. Hence arises the phenomenon of multiple resonance, discovered by Messrs. Sarasin and De la Rive, which at first seemed irreconcilable with the theory.

On the other hand, we know that light does not exactly follow the laws of geometrical optics, and the discrepancy, due to diffraction, increases proportionately to the wave length. With the great waves of the Hertzian undulations these phenomena must assume enormous importance and derange everything. It is doubtless fortunate, for the moment at least, that our means of observation are as coarse as they are, for otherwise the simplicity which struck us would give place to a dedalian complexity in which we should lose our way. No doubt a good many perplexing anomalies have been due to this. For the same reason the experiments to prove a refraction of the electrical waves can hardly be considered as demonstrative.

It remains to speak of a difficulty still more grave, though doubtless not insurmountable. According to Maxwell, the coefficient of electrostatic induction of a transparent body ought to be equal to the square of its index of refraction. Now this is not so. The few bodies which follow Maxwell's law are exceptions. The phenomena are plainly far more complex than was at first thought. But we have not yet been able to make out how matters stand, and the experiments conflict with one another.

Much, then, remains to be done. The identity of light with a vibratory motion in electricity is henceforth something more than a seductive hypothesis; it is a probable truth. But it is not yet quite proved.

Note I.—Since the above was written another great step has been taken. M. Blondlot has virtually succeeded, by ingenious experimental contrivances, in directly measuring the velocity of a disturbance along a wire. The number found differs little from the ratio of the units; that is, from the velocity of light, which is 300,000 kilometers per second. Since the interference experiments made at Geneva by Messrs. Sarasin and De la Rive have shown, as I said above, that induction is propagated in air with the same velocity as an electric disturbance which follows a conducting wire, we must conclude that the velocity of the induction is the same as that of light, which is a confirmation of the ideas of Maxwell.

M. Fizeau had formerly found for the velocity of electricity a

number far smaller, about 180,000 kilometers. But there is no contradiction. The currents used by M. Fizeau, though intermittent, were of small frequency and penetrated to the axis of the wire, while the currents of M. Blondlot, oscillatory and of very short period, remained superficial and were confined to a layer of less than a hundredth of a millimeter in thickness. One may readily suppose the laws of propagation are not the same in the two cases.

NOTE II.—I have endeavored above to render the explanation of the electrostatic attractions and of the phenomena of induction comprehensible by means of a simile. Now let us see what Maxwell's idea is of the cause which produces the mutual attractions of currents.

While the electrostatic attractions are taken to be due to a multitude of little springs—that is to say, to the elasticity of the ether—it is supposed to be the living force and inertia of the same fluid which produce the phenomena of induction and electrodynamical effects.

The complete calculation is far too extended for these pages, and I shall again content myself with a simile. I shall borrow it from a well known instrument—the centrifugal governor.

The living force of this apparatus is proportional to the square of the angular velocity and to the square of the distance of the balls.

According to the hypothesis of Maxwell, the ether is in motion in galvanic currents, and its living force is proportional to the square of the intensity of the current, which thus correspond, in the parallel I am endeavoring to establish, to the angular velocity of rotation.

If we consider two currents in the same direction, the living force, with equal intensity, will be greater the nearer the currents are to one another. If the currents have opposite directions, the living force will be greater the farther they are apart.

In order to increase the angular velocity of the regulator and consequently its living force, it is necessary to supply it with energy and consequently to overcome a resistance which we call its inertia.

In the same way, in order to increase the intensity of a current, we must augment the living force of the ether, and it will be necessary to supply it with energy and to overcome a resistance which is nothing but the inertia of the ether and which we call the induction.

The living force will be greater if the currents are in the same direction and near together. The energy to be furnished the counter electromotive force of induction will be greater. This is what we express when we say that the mutual action of two currents is to be added

to their self-induction. The contrary is the case when their directions are opposite.

If we separate the balls of the regulator, it will be necessary, in order to maintain the angular velocity, to furnish energy, because with equal angular velocity the living force is greater the more the balls are separated.

In the same way, if two currents have the same direction and are brought toward one another, it will be necessary, in order to maintain the intensity to supply energy, because the living force will be augmented. We shall, therefore, have to overcome an electromotive force of induction which will tend to diminish the intensity of the currents. It would tend on the contrary to augment it, if the currents had the same direction and were carried apart, or if they had opposite directions and were brought together.

Finally, the centrifugal force tends to increase the distance between the balls, which would augment the living force were the angular velocity to be maintained.

In like manner, when the currents have the same direction, they attract each other—that is to say, they tend to approach each other, which would increase the living force if the intensity were maintained. If their directions are opposed they repel one another and tend to separate, which would again tend to increase the living force were the intensity kept constant.

Thus the electrostatic effects would be due to the elasticity of the ether and the electrodynamical phenomena to the living force. Now, ought this elasticity itself to be explained, as Lord Kelvin thinks, by rotations of small parts of the fluid? Different reasons may render this hypothesis attractive; but it plays no essential part in the theory of Maxwell, which is quite independent of it.

In the same way, I have made comparisons with divers mechanisms. But they are only similes, and pretty rough ones. A complete mechanical explanation of electrical phenomena is not to be sought in the volumes of Maxwell, but only a statement of the conditions which any such explanation has to satisfy. Precisely what will confer long life on the work of Maxwell is its being unentangled with any special mechanical hypothesis.


ROENTGEN

W. K. RÖNTGEN

WILHELM KONRAD VON ROENTGEN was born at Lennep, Prussia, in 1845. He was educated at Zurich, and became professor of physics at Strasburg, and in 1885 at Würzburg. His discovery of the so-called X-rays was made in 1895.

THE X-RAYS

I.—UPON A NEW KIND OF RAYS

1. If the discharge of a great Ruhmkorff induction coil be passed through a Hittorf vacuum tube, or a Lenard's, Crookes', or similar apparatus containing a sufficiently high vacuum, then, the tube being covered with a close layer of thin black pasteboard and the room darkened, a paper screen covered on one side with barium-platinum cyanide and brought near the apparatus will be seen to glow brightly and fluoresce at each discharge whichever side of the screen is toward the vacuum tube. The fluorescence is visible even when the screen is removed to a distance of 2 meters from the apparatus.

The observer may easily satisfy himself that the cause of the fluorescence is to be found at the vacuum tube and at no other part of the electrical circuit.

2. It is thus apparent that there is here an agency which is able to pass through the black pasteboard impenetrable to visible or ultra violet rays from the sun or the electric arc, and having passed through is capable of exciting a lively fluorescence, and it is natural to inquire whether other substances can be thus penetrated.

It is found that all substances transmit this agency, but in very different degree. I will mention some examples. Paper is very transmissible.

I observed fluorescence very distinctly behind a bound book of about 1,000 pages. The ink presented no appreciable obstacle. Similarly fluorescence was seen behind a double whist pack. A single card

held between the fluorescent screen and the apparatus produced no visible effect. A single sheet of tin foil, too, produces hardly any obstacle, and it is only when several sheets are superposed that their shadow appears distinctly on the screen. Thick wooden blocks are transmissible. Slabs of pine 2 or 3 centimeters thick absorb only very little. A plate of aluminum about 15 millimeters thick diminished the effect very considerably, but did not cause the fluorescence to entirely disappear. Blocks of hard rubber several centimeters thick still transmitted the rays.

Glass plates of equal thickness behave very differently according to whether they contain lead (flint glass) or not. The first class are much less transmissible than the second.

If the hand is held between the vacuum tube and the screen, the dark shadow of the bones is seen upon the, much lighter shadow outline of the hand. Water, carbon, bisulphide, and various other liquids investigated proved very transmissible. I could not find that hydrogen was more transmissible than air. The fluorescence was visible behind plates of copper, silver, lead, gold, and platinum, when the thickness of the plate was not too great. Platinum 0.2 millimeter thick is still transmissible, and silver and copper plates may be still thicker. Lead 1.5 millimeters thick is practically impenetrable, and advantage was frequently taken of this characteristic. A wooden stick of 20 millimeters square cross section, having one side covered with white lead, behaved differently when interposed between the vacuum tube and the screen according as the X-rays traversed the block parallel to the painted side or were compelled to pass through it. In the first case there was no effect appreciable, while in the second a dark shadow was thrown on the screen. Salts of the metals, whether solid or in solution, are to be ranged in almost the same order as the metals themselves for transmissibility.

3. These observations and others lead to the conclusion that the transmissibility of equal thicknesses of different substances depends on their density. At least no other characteristic exerts so marked an influence as this.

The following experiment shows, however, that the density is not the sole factor. I compared the transmissibility of nearly equally thick plates of glass, aluminum, calcspar, and quartz. The density of these substances is substantially the same, and yet it was quite evident that the calcspar was considerably less transmissible than the others, which are about alike in this respect.

4. All bodies became less transmissible with increasing thickness. For the purpose of finding a relation between transmissibility and thickness I have made photographic exposures, in which the photographic plate was partly covered with a layer of tin foil consisting of a progressively increasing number of sheets. I shall make a photometric measurement when I am in possession of a suitable photometer.

5. Sheets were rolled from platinum, lead, zinc, and aluminum of such thickness that all appeared to be equally transmissible. The following table gives the measured thickness in millimeters, the relative thickness compared with platinum, and the specific gravity:

	Thickness.	Relative Thickness.	Specific Gravity.
Platinum	0.018	1	21.5
Lead	0.05	3	11.3
Zinc	0.10	6	7.1
Aluminum	3.5	200	2.6

From these values it may be seen that the transmissibility of plates of different metals so chosen that the product of the thickness and density is constant would not be equal. The transmissibility increases much faster than this product falls off.

6. The fluorescence of barium-platinum-cyanide is not the only action by which X-rays may be recognized. It should be remarked that they cause other substances to fluoresce, as for example the photophorescent calcium compounds, uranium glass, common glass, calcspar, rock salt, etc.

It is of particular importance from many points of view that photographic dry plates are sensitive to X-rays. It thus becomes possible to fix many phenomena so that deceptions are more easily avoided; and I have where practicable checked all important observations made with a fluorescent screen by photographic exposures.

It appears questionable whether the chemical action upon the silver salts of the photographic plate is produced directly by the X-rays. It is possible that this action depends upon the fluorescent light which, as is mentioned above, may be excited in the glass plate, or perhaps in the gelatine film. "Films" may indeed be made use of as well as glass plates.

I have not as yet obtained experimental evidence that the X-rays are capable of giving heat. This characteristic might, however, be assumed as present, since in the excitation of fluorescent phenomena the capacity

of the energy of the X-rays for transformation is proved, and since it is certain that of the X-rays falling upon a body not all are given up.

The retina of the eye is not sensitive to these rays. Nothing is to be noticed by bringing the eye near the vacuum tube, although according to the preceding observations the media of the eye must be sufficiently transmissible to the rays in question.

7. After I had discovered the transmissibility of various bodies of relatively great thickness I hastened to investigate whether or not the X-rays were refracted in passing through a prism. Experiments with water and carbon bisulphide in mica prisms of 30 degrees refracting angle showed no deviation either when observations were made with the fluorescent screen or with the photographic plate. For comparison, the deviation of light rays was observed under the same conditions. The refracted portion lay from 10 to 20 centimeters distant from that not refracted. With prisms of hard rubber and aluminum of about 30 degrees refracting angle I obtained exposures on a photographic plate which perhaps indicated a slight refraction. This is, however, very doubtful and the deviation is, if present, so small that the index of refraction for X-rays in these substances can not exceed 1.05. I could not observe with the fluorescent screen any deviation in these cases. Experiments with prisms of the denser metals have so far yielded no certain results on account of the slight transmissibility and the consequent decrease of the intensity of the transmitted ray.

In consideration of these results on the one hand, and on the other of the importance of the question whether or not the X-rays in passing from one medium to another undergo refraction, it is very gratifying that this question may be investigated by other means than by the help of prisms. Finely pulverized bodies in suitable layers allow but little light to pass, in consequence of refraction and reflection. If now the X-rays are transmitted equally well through powder as through the coherent substance, equal masses being presupposed, it is proved that neither refraction nor regular reflection is present in any marked degree. This experiment was performed using finely pulverized rock-salt, finely divided silver, obtained by electrolysis, and the zinc dust so frequently utilized in chemical processes. In no case was any difference in transmissibility between the powder and the coherent substance detected either by the use of the fluorescent screen or the photographic plate.

It follows of course from the results thus obtained that the X-rays can not be concentrated by the use of lenses; and, indeed, a great hard

rubber lens and a glass lens actually proved without effect. The shadow of a round rod is darker in the middle than at the edges, while that of a tube which is filled with some substance more transmissible than the material of which the tube is composed is darker at the edges than at the center.

8. The question as to the reflection of X-rays is so far settled by the experiments already described that no marked regular reflection was to be found with any of the substances examined. Other experiments which I will here pass over lead to the same results.

Nevertheless an observation should be mentioned which indicated at first glance an opposite result. A photographic plate shielded from the action of light rays by a black paper was exposed to X-rays so that the glass side was toward the discharge tube. The sensitive film was partially covered with bright plates of platinum, lead, zinc, and aluminum, arranged in a star-shaped figure. Upon development it was observed that the darkening of the film under the platinum, the lead, and especially the zinc was distinctly greater than in the other parts. No such effect was produced by the aluminum. Thus it seemed as if the three metals mentioned reflected. However, there were other causes to be conceived which might have produced the increased darkening, and in order to be sure I performed a second experiment, interposing a thin sheet of aluminum foil (very transmissible to X-rays, but not to those of the ultraviolet) between the metals and the sensitive film. Since in this case again practically the same result was obtained, the fact of reflection of X-rays by the metals above mentioned is established.

Taking this result together with the observation that powder is as transmissible as coherent substance, and further, that bodies with rough surfaces behave in the transmission of X-rays and also in the experiments just described exactly like polished bodies, the conclusion is reached that there is, as before remarked, no regular reflection, but that the bodies behave toward X-rays in the same manner as a turbid medium with reference to light.

As I have not been able to discover any refraction in the passage from one medium to another, it appears as if the X-rays travel with equal velocity in all bodies, and hence in a medium which is everywhere present and in which the particles of the bodies are embedded. These latter act as a hindrance to the propagation of the X-rays, which is in general greater the greater the density of the body in question.

9. In accordance with this supposition it might be possible that the

arrangement of the molecules of the body would exert an influence on its transmissibility, and that, for example, a piece of calcspar would be unequally transmissible for equal thicknesses when the rays passed along or at right angles to the axis. Experiments with calcspar and quartz gave, however, a negative result.

10. It will be recalled that Lenard, in his beautiful experiments on the transmission of the Hittorf cathode rays through thin aluminum foil, obtained the result that these rays are disturbances in the ether, and that they diffuse themselves in all bodies. We may make a similar statement with regard to our rays.

In his last research Lenard has determined the relative absorption of different substances for the cathode rays, and in determining the same for air at atmospheric pressure has given the values 4.10, 3.40, 3.10 as referred to 1 centimeter thickness according to the density of the gas in the discharge tube. Judging from the length of spark observed, I have, in my researches, generally employed tubes of about equal exhaustion and only seldom those of much greater or less density. Using the photometer of L. Weber, the best at my command, I compared the intensity of fluorescence on the screen in two positions distant 100 and 200 millimeters, respectively, from the discharge tube. From the results of these experiments, agreeing well with each other, it appeared that the intensity varies inversely as the square of the distance. Hence the air absorbs a much smaller portion of the X-rays passing through it than of cathode rays. This result is in accord with the observation above mentioned, that it is possible to distinguish fluorescence at 2 meters distance from the discharge tube.

Most other substances are, like the air, more transmissible for X-rays than for the cathode rays.

11. Another very noteworthy difference between the behavior of the cathode rays and the X-rays was exhibited in that I was unable to produce any deviation of the latter by the action of the most powerful magnetic fields. The property of being subject to deviation by magnets is, on the other hand, very characteristic of the cathode rays. Hertz and Lenard have observed various kinds of cathode rays which "are to be distinguished by their differences in their capacities for exciting phosphorescence in their absorbability and in their deviation by the magnet," but a considerable magnetic deviation was to be observed with all of them, and I do not believe that this characteristic would be given up except for the most urgent reasons.

12. According to the results of experiments particularly directed to discover the source of the X-rays, it is certain that the part of the wall of the discharge tube which most strongly fluoresces is the principal starting point. The X-rays therefore radiate from the place where, according to various observers, the cathode rays meet the glass wall. If one diverts the cathode rays within the tube by a magnet, the source of the X-ray is also seen to change its position so that these radiations still proceed from the end points of the cathode rays. The X-rays being undeviated by magnets cannot, however, be simply cathode rays passing unchanged through the glass wall. The greater density of the gas outside of the discharge tube cannot, according to Lenard, be made answerable for the great difference of the deviation.

I come therefore to the results that the X-rays are not identical with the cathode rays, but that they are excited by the cathode rays in the glass wall of the vacuum tube.

13. This generating action takes place not only in glass, but as I observed it in apparatus with aluminum walls 2 millimeters thick, exists also for this metal. Other substances will be investigated.

14. The warrant for giving the title "rays" to the agent which proceeds from the wall of the discharge tube arose in part from the quite regular formation of shadows appearing when more or less transmissible substances are interposed between the generating apparatus and a phosphorescent screen or photographic plate. I have many times observed and sometimes photographed such shadow forms, in whose production there lies a particular charm. I have, for example, photographs of the shadow of the profile of a door which separates the two rooms, in one of which was the discharge apparatus, in the other the photographic plate; of the shadow of the hand bones; of the shadow of a wooden spool wound with wire; of a set of weights in a box; of a compass in which the magnetic needle is quite inclosed in metal; of a piece of metal which is shown to lack homogeneity by the use of X-rays, etc.

The propagation of the X-rays in right lines is shown by pin-hole photography, which I have been able to do with the discharge apparatus covered with black paper. The picture is weak, but unmistakably correct.

15. I have much sought to obtain interference phenomena with X-rays, but unfortunately—perhaps on account of their slight intensity—without result.

16. Experiments have been begun to see if electrostatic forces can in any way influence X-rays, but these are not yet finished.

17. If the question is asked what the X-rays—which certainly are not cathode rays—really are, one might at first, on account of their lively fluorescent and chemical action, compare them to ultra-violet light. But here one falls upon serious difficulties. Thus, if the X-rays were ultra-violet light, then this light must possess the following characteristics:

(*a*) That in passing from air into water, carbon bisulphide, aluminum, rock salt, glass, zinc, etc., it experiences no notable refraction.

(*b*) That it is not regularly reflected by these substances.

(*c*) That it cannot be polarized by the usual materials.

(*d*) That its absorption by substances is influenced by nothing so much as by their density.

In other words, one must assume that these ultra-violet radiations comport themselves quite differently from all previously known infra red, visible, and ultra-violet rays.

I have not been able to admit this, and have sought some other explanations.

A kind of relation seems to subsist between the new radiation and light radiation, or at least the shadow formation, the fluorescence, and the chemical action, which are common phenomena of these two kinds of radiation, point in this direction. It has been long known that longitudinal as well as transverse vibrations are possible in the ether, and according to various physicists must exist. To be sure, their existence has not, up to the present time, been proved, and hence their characteristics have not thus far been experimentally investigated.

Should not the new radiations be ascribed to longitudinal vibrations in the ether? I may say that in the course of the investigation this hypothesis has impressed itself more and more favorably with me, and I venture to propose it, although well aware that it requires much further examination.

WUERZBURG, PHYSIK. INSTITUT D. UNIV., *December, 1895*.

II.—UPON A NEW KIND OF RAYS (ABSTRACT.)

As my work must be interrupted for several weeks, I take the opportunity of presenting in the following some new results:

18. At the time of my first publication I was aware that the X-rays have the property of discharging electrified bodies, and I intimated that it was the X-rays and not the cathode rays passing unchanged through the aluminum window of his apparatus which produced the effect

described by Lenard on electrified bodies at a distance. I have, however, delayed publication of my experiments until I could present conclusive results.

These can be obtained only when the observations are carried on in a room which is not only completely insulated from the electrostatic forces emanating from the vacuum tube, the conducting wires, the induction apparatus, etc., but is also closed to the air which comes in the neighborhood of the discharge apparatus.

For this purpose I had a box constructed by soldering together zinc sheets, and this box was large enough to contain me and the necessary apparatus, and was air-tight with the exception of an opening which could be closed by a zinc door. The side opposite to the door was mostly lined with lead, and immediately adjacent to the discharge tube an opening 4 centimeters wide was cut in the lead and zinc wall, and its place filled up air-tight with aluminum foil. Through this window passed the X-rays to be investigated. I have with this apparatus verified the following results:

(*a*) Positively or negatively electrified bodies placed in air are discharged when immersed in X-rays, and the action is the more rapid the more intense the radiations. The intensity of the rays is determined by their action upon a fluorescent screen or a photographic plate.

It is in general immaterial whether the electrified substance is a conductor or non-conductor. Thus far I have discovered no difference in the behavior of different bodies relative to the rapidity of their discharge, or between positive or negative charges. These points are, however, open to further investigation.

(*b*) When an electrified conductor is surrounded by a solid insulator, as for example, paraffine, the radiation produces the same effect as would the flashing of the insulating shell by a flame placed in contact with the ground.

(*c*) If this insulator be in its turn closely surrounded by a grounded conductor and both itself and this outer conductor be transmissible to X-rays, the action of the X-radiations upon the inner conductor is unnoticeable with the apparatus at my command.

(*d*) The observations recorded under (*a*), (*b*), and (*c*) indicate that the air through which X-rays pass possesses the property of discharging any electrified bodies with which it comes in contact.

(*e*) If this be indeed the case, and if the air retains for some considerable time this property imparted to it by the X-rays, it must be pos-

sible to discharge electrified bodies not themselves under the influence of X-rays by bringing to them air which has been subject to these radiations.

One may satisfy himself in various ways that this is the case. The following, though perhaps not the simplest method, may be mentioned:

I employed a brass tube 3 centimeters wide and 45 centimeters long. At 1 centimeter's distance from one end a portion of the tube was cut away and replaced by a thin sheet of aluminum. At the other end there was introduced a brass ball, which was supported by a metal support, and this end was closed air-tight. Between the brass ball and the closed end of the tube a side tube was soldered in, which was connected with an air-pump. By this means a current of air was made to flow by the brass ball, after having passed the aluminum window. The distance from the ball to the window was 20 centimeters.

I mounted this tube in the zinc box in such a manner that the X-rays entered the tube at right angles to its axis, and the insulated ball lay outside the reach of these rays, in the shadow. The tube and zinc box were placed in contact and the ball was connected with a Hankel electroscope.

It was shown that a charge on the ball, whether positive or negative, was not influenced by X-rays so long as the air remained quiet in the tube, but that a marked diminution of the charge was produced by sucking a strong current of air through. If the ball was kept at constant potential by connecting it with accumulators, and a continuous current of air was kept flowing in the tube, an electrical current was set up just as if the ball was connected with the walls of the tube by a conductor of high resistance. * * *

20. In section 13 of my first article it was stated that the X-rays may be generated not only in glass but in aluminum. In conducting experiments in this direction no solid bodies were found which were not capable of producing X-rays when under the influence of cathode rays. I know no reason to suppose that liquids and gases also do not act similarly.

Different substances, however, possess this property in different degrees. For example, if cathode rays are caused to fall upon a plate of which one-half is composed of platinum foil 0.3 millimeter thick and the other half of aluminum 1 millimeter thick, one may observe in the photographic image taken with the pinhole camera that the platinum foil sends out many more X-rays from the side bombarded by the

cathode rays than does the aluminum on the same side. But from the back side of the plate there go out almost no X-rays from the platinum, while the aluminum sends out a relatively large number. These latter rays are generated at the front layers of the aluminum and pass through the plate.

It should be remarked that these observations have a practical significance. For the generation of X-rays of the greatest possible intensity my experience recommends the employment of platinum. I have used for some weeks with advantage a discharge apparatus having a concave mirror of aluminum as cathode, and as annode a platinum plate placed in the center of curvature, and at an angle of 45 degrees with the axis.

21. The X-rays proceed from the annode with this apparatus. As I have concluded from experiments with apparatus of various forms, it is immaterial with regard to the intensity of the X-rays whether they proceed from the annode or not. * * *

(WUERZBURG, PHYSIK. INSTITUT D. UNIVERSITAET, *March 9, 1896.*)

III.—FURTHER OBSERVATIONS ON THE PROPERTIES OF X-RAYS (EXTRACT).

With reference to practical applications, the observation of the distribution of intensity of the rays proceeding from the platinum plate has some value in connection with the formation of shadow pictures by means of X-rays. In accordance with the observations above recorded it is to be recommended that the discharge tube be so arranged that the rays employed for formation of pictures be those making a large angle, though not much exceeding 80 degrees, with the platinum plate. In this way the sharpest possible delineation will be obtained, and if the platinum plate is flat and the construction of the tube such that the rays proceeding obliquely pass through not much greater thickness of glass than those going out at right angles to the platinum plate, then no material loss in intensity will be experienced in this arrangement.

5. If two plates of different substances are equally transmissible this equality will not in general be retained for another pair of plates of the same substances with thicknesses altered in the same ratio. This fact may be shown very easily by the use of thin sheets, as, for example, of platinum and aluminum. I used for this purpose platinum foil 0.0026 millimeter thick and aluminum foil 0.0299 millimeter thick. I found in one instance that one sheet of platinum was equally transmissible with

six sheets of aluminum; but the transmissibility of two sheets of platinum was less than that of twelve sheets of aluminum and about equal to that of sixteen sheets of the latter metal. Using another discharge tube, I found 1 platinum equal 8 aluminum, but 8 platinum equal 90 aluminum. From these experiments it follows that the ratio of thicknesses of platinum and aluminum of equal transmissibility is less the thicker the sheets under examination.

6. The ratio of the thicknesses of two equally transmissible plates of different material is dependent on the thickness and the material of the body, as, for instance, the glass wall of the discharge tube, through which the rays have to pass before they reach the plates investigated.

* * *

7. The experiments described in sections 4, 5, and 6 relate to the alterations which the X-rays proceeding from a discharge tube experience in their transmission through different substances. It will now be shown that one and the same body may for the same thickness be unequally transmissible for rays emitted from different discharge tubes.

In the following table are given the values of the transmissibility of an aluminum plate 2 millimeters thick for the rays given out by different tubes:

	Tube.					
	1	2	3	4	2	5
Transmissibility for vertically incident rays of a 2-millimeter thick aluminum plate........	0.0044	0.22	0.30	0.39	0.50	0.59

The discharge tubes were not materially different in their construction or in the thickness of their glass wall, but varied in the density of the gas within them, and hence in the potential required to produce discharge. Tube 1 required the least and tube 5 the greatest potential, or, as we may say for short, the tube 1 is the "softest" and tube 5 the "hardest." The same Ruhmkorff in direct connection with the tubes, the same circuit breaker, and the same current strength in the primary circuit were used in all cases.

Various other substances which I have investigated behaved similarly to aluminum. All are more transmissible to rays from harder tubes. This fact seemed to me particularly worthy of attention.

The relative transmissibility of plates of different substances proved also to be dependent on the hardness of the discharge tube employed. The ratio of the thickness of platinum and aluminum plates of equal

transmissibility becomes less the harder the tubes from which the rays proceed, or, referring to the results just given, the less the rays are absorbed.

The different behavior of rays excited in tubes of different hardness is also made apparent in the well known shadow picturing of hands, etc. With a soft tube a dark shadow is obtained, in which the bones are little prominent; when a harder tube is used the bones are very distinct and visible in all their details, whereas the softer portions are less marked, and with very hard tubes even the bones themselves become only weak shadows. From these considerations it appears that the choice of the tube must be governed by the character of the objects which it is desired to portray.

It remains to remark that the quality of rays proceeding from one and the same tube depends on various conditions. Of these the most important are the following: (1) The action of the interrupter, or, in other words, the course of the primary current. In this connection should be mentioned the phenomena frequently observed that particular ones of the rapidly succeeding discharges excite X-rays which are not only more intense, but which also differ from the others in their absorption. (2) The character of the sparks which appear in the secondary circuit of the apparatus. (3) The employment of a Tesla transformer. (4) The degree of evacuation of the discharge tube (as already stated). (5) The varying, but as yet not satisfactorily known, procedure within the discharge tube. Separate ones among these conditions require further comment. * * *

The hardness of a tube had been considered to be brought about solely by the continuation of the evacuation by means of the pump; but this characteristic is affected in other ways. Thus a sealed tube of medium hardness becomes gradually harder by itself—unfortunately to the shortening of the period of its usefulness when used in a suitable manner for the production of X-rays, that is to say, when discharges which do not cause the platinum to glow or at least to glow only weakly are passed through. A gradual self-evacuation is thus effected.

With a tube thus become very hard I took a very fine photograph of a double-barreled gun with inserted cartridges, which showed all the details of the cartridges, the inner faults of the Damascus barrels, etc., very sharply and distinctly. The distance from the platinum plate of the discharge tube to the photographic plate was 15 centimeters and the exposure twelve minutes—comparatively long in consequence of the small photographic action of the very slightly absorbable rays (see

below). The Duprez interrupter had to be replaced by the Foucault form. It would be of interest to construct tubes which would make it possible to use still higher potentials than before.

Self-evacuation has been above assigned as the cause of the growing hardness of sealed tubes, but this is not the only cause. There are changes in the electrodes which produce this effect. I do not know the nature of these changes. * * *

The observations recorded in these paragraphs and others not given have led me to the view that the composition of the rays proceeding from a platinum anode of a discharge tube depends upon the frequency and form of the discharge current. The degree of tenuity, the hardness, is important only because the form of the discharge is thereby influenced. If it were possible to produce the proper form of discharge for the generation of X-rays in any other way, the X-rays might be obtained with relatively high pressures.

9. The results appearing in the five preceding paragraphs have been those most evidently to be derived from the accompanying experiments. Summing up these separate results, and being guided in part by and X-rays, one arrives at the following conclusions:

(*a*) The radiations emitted by a discharge tube consist of a mixture of rays of different absorbability and intensity.

(*b*) The composition of this mixture is in a marked degree dependent on the frequency and form of the discharge current.

(*c*) The rays receiving preference in absorption vary with different bodies.

(*d*) Since the X-rays are generated by the cathode rays and have in common with them various characteristics—as the exciting of fluorescence, photographic and electrical actions, an absorbability depending in a marked degree on the density of the medium traversed, etc.—the conjecture is prompted that both phenomena are processes of the same nature. Without committing myself unconditionally to this view, I may remark that the results of the last paragraphs are calculated to raise a difficulty in the way of this hypothesis. This difficulty consists in the great difference between the absorption of the cathode rays investigated by Lenard and the X-rays, and second, that the transmissibility of bodies for the cathode rays is related to their density by other laws than those which govern their transmissibility for X-rays.

With regard to the first point, considerations present themselves under two heads: (1) As we have seen in section 7, there are X-rays of

different absorbability, and the investigations of Hertz and Lenard show that the cathode rays are similarly to be discriminated. While the "softest" tubes investigated generated rays much less subject to absorption than any cathode rays investigated by Lenard, yet there is no reason to doubt the possibility of X-rays of greater absorbability, and cathode rays of less. It therefore appears probable that in future investigations rays will be found bridging over the gap between X-rays and cathode rays, so far as their absorption is concerned. (2) We found in section 4 that the specific transmissibility of a body becomes less the thinner the plate passed through. Consequently, had we made use in our experiments of plates as thin as those employed by Lenard it would have been found that the X-rays were more nearly like those of Lenard in their absorbability.

10. Besides the fluorescent phenomena, there may be excited by X-rays photographic, electric, and other actions, and it is of interest to know how far these various manifestations vary in similar ratio when the source of the rays is altered. I must restrict myself to a comparison of the first two phenomena. * * *

A hard and a soft tube were so adjusted as to give equally bright fluorescence as compared by means of the photometer described in section 2. Upon substituting a photographic plate in the place of the fluorescent screen it was found, on development, that the portion subject to the rays from the hard tube was blackened to a less degree than the other. The rays, though producing equal fluorescence, were thus for photographic purposes unequally active. * * *

The great sensitiveness of a photographic plate even for rays from tubes of medium hardness is illustrated by an experiment in which 96 films were superposed, placed at a distance of 25 centimeters from the discharge tube, and exposed five minutes with due precautions to protect the films from the radiations of the air. A photographic action was apparent on the last film, although the first was scarcely over-exposed. * * *

If the intensity of the radiations is augmented by increasing the strength of the primary current, the photographic action increases in the same measure as the intensity of the fluorescence. In this case, as in the case where the intensity of the radiation was increased by an alteration of the distance of the fluorescent screen, the brightness of the fluorescence is at least approximately proportional to the intensity of the radiation. This rule should not, however, be too generally applied.

11. In conclusion, mention should be made of the following particulars:

With a discharge tube of proper construction, and not too soft, the X-rays are chiefly generated in a spot of not more than 1 or 2 millimeters diameter where the cathode rays meet the platinum plate. This, however, is not the sole source. The whole plate and a part of the tube walls emit X-rays, though in less intensity. Cathode rays proceed in all directions, but their intensity is considerable only near the axis of the concave cathode mirror, and, consequently, the X-rays are strongly emitted only near the point where this axis meets the platinum plate. When the tube is very hard and the platinum thin, many rays proceed also from the rear surface of the platinum plate, but, as may be shown by the pinhole camera, chiefly from the spot lying on the axis of the mirror. * * *

I can confirm the observation of G. Brandes that the X-rays are able to produce a sensation of light upon the retina of the eye. In my record book appears a notice entered in the early part of November, 1895, to the effect that when in a darkened chamber, near a wooden door, I perceived a weak appearance of light when a Hittorf tube upon the other side of the door was put in operation. Since this appearance was only once observed, I regarded it as a subjective, and the reason that it was not then repeatedly observed lay in the fact that other tubes were substituted for the Hittorf tube which were less completely evacuated and not provided with platinum anodes. The Hittorf tube furnishes rays of slight absorbability on account of its high vacuum, and, at the same time, of great intensity on account of the employment of a platinum anode for the reception of the cathode rays. * * *

With the tubes now in use I can easily repeat the Brandes experiment. * * *

Since the beginning of my investigation of X-rays I have repeatedly endeavored to produce diffraction phenomena with them. I obtained at various times, when using narrow slits, appearances similar to diffraction effects, but when modifications were made in the conditions for the purpose of thoroughly proving the accuracy of this explanation of the phenomena it was found in each case that the appearances were produced in other ways than by diffraction. I know of no experiment which gives satisfactory evidence of the existence of diffraction with the X-rays.

W. H. PREECE

William Marconi was born near Bologna, Italy, in 1875. He became an electrical engineer and early gave his attention to the transmission of the Hertz electric waves without wires. The description given below is by W. H. Preece, who invented a system which proved successful over short distances some years before Marconi.

WIRELESS TELEGRAPHY: THE PREECE AND MARCONI SYSTEMS

Science has conferred one great benefit on mankind. It has supplied us with a new sense. We can now see the invisible, hear the inaudible, and feel the intangible. We know that the universe is filled with a homogeneous continuous elastic medium which transmits heat, light, electricity and other forms of energy from one point of space to another without loss. The discovery of the real existence of this "ether" is one of the great scientific events of the Victorian era. Its character and mechanism are not yet known to us. All attempts to "invent" a perfect ether have proved beyond the mental powers of the highest intellects. We can only say with Lord Salisbury that the ether is the nominative case of the verb "to undulate." We must be content with a knowledge of the fact that it was created in the beginning for the transmission of energy in all its forms, that it transmits these energies in definite waves and with a known velocity, that it is perfect of its kind, but that it still remains as inscrutable as gravity or light itself.

Any disturbance of the ether must originate with some disturbance of matter. An explosion, cyclone, or vibratory motion may occur in the photosphere of the sun. A disturbance or wave is impressed on the ether. It is propagated in straight lines through space. It falls on Jupiter, Venus, the Earth, and every other planet met with in its course, and any machine, human or mechanical, capable of responding to its undulations indicates its presence. Thus the eye supplies the sensation

of light, the skin is sensitive to heat, the galvanometer indicates electricity, the magnetometer indicates disturbances in the earth's magnetic field. One of the greatest scientific achievements of our generation is the magnificent generalization of Clerk-Maxwell that all these disturbances are of precisely the same kind, and that they differ only in degree. Light is an electromagnetic phenomenon, and electricity in its progress through space follows the laws of optics. Hertz proved this experimentally, and few of us who heard it will forget the admirable lecture on "The Work of Hertz" given in this hall by Prof. Oliver Lodge three years ago.

By the kindness of Prof. Silvanus Thompson I am able to illustrate wave transmission by a very beautiful apparatus devised by him. At one end we have the transmitter or oscillator, which is a heavy suspended mass to which a blow or impulse is given, and which, in consequence, vibrates a given number of times per minute. At the other end is the receiver or resonator, timed to vibrate to the same period. Connecting the two together is a row of leaden balls suspended so that each ball gives a portion of its energy at each oscillation to the next in the series. Each ball vibrates at right angles to or athwart the line of propagation of the wave, and as they vibrate in different phases you will see that a wave is transmitted from the transmitter to the receiver. The receiver takes up these vibrations and responds in sympathy with the transmitter. Here we have a visible illustration of that which is absolutely invisible. The wave you see differs from a wave of light or of electricity only in its length or in its frequency. Electric waves vary from units per second in long submarine cables to millions per second when excited by Hertz's method. Light waves vary per second between 400 billions in the red to 800 billions in the violet, and electric waves differ from them in no other respect. They are reflected, refracted and polarized, they are subject to interference, and they move through the ether in straight lines with the same velocity, viz, 186,400 miles per second—a number easily recalled when we remember that it was in the year 1864 that Maxwell made his famous discovery of the identity of light and electric waves.

Electric waves, however, differ from light waves in this, that we have also to regard the direction at right angles to the line of propagation of the wave. The model gives an illustration of that which happens along a line of electric force; the other line of motion I speak of is a circle around the point of disturbance, and these lines are called lines

of magnetic force. The animal eye is tuned to one series of wave; the "electric eye," as Lord Kelvin called Hertz's resonator, to another. If electric waves could be reduced in length to the forty-thousandth of an inch we should see them as colors.

One more definition, and our ground is cleared. When electricity is found stored up in a potential state in the molecules of a dielectric like air, glass, or gutta-percha the molecules are strained, it is called a charge, and it establishes in its neighborhood an electric field. When it is active, or in its kinetic state in a circuit, it is called a current. It is found in both states—kinetic and potential—when a current is maintained in a conductor. The surrounding neighborhood is then found in a state of stress, forming what is called a magnetic field.

In the first case the charges can be made to rise and fall, and to surge to and fro with rhythmic regularity, exciting electric waves along each line of electric force at very high frequencies, and in the second case the currents can rise or alternate in direction with the same regularity, but with very different frequencies, and originate electromagnetic waves whose wave fronts are propagated in the same direction.

The first is the method of Hertz, which has recently been turned to practical account by Mr. Marconi, and the second is the method which I have been applying, and which, for historical reasons, I will describe to you first.

In 1884 messages sent through insulated wires buried in iron pipes in the streets of London were read upon telephone circuits erected on poles above the house tops, 80 feet away. Ordinary telegraph circuits were found in 1885 to produce disturbances 2,000 feet away. Distinct speech by telephone was carried on through one-quarter of a mile, a distance that was increased to 1¼ miles at a later date. Careful experiments were made in 1886 and 1887 to prove that these effects were due to pure electromagnetic waves, and were entirely free from any earth-conduction. In 1892 distinct messages were sent across a portion of the Bristol Channel, between Penarth and Flat Holm, a distance of 3.3 miles.

Early in 1895 the cable between Oban and the Isle of Mull broke down, and as no ship was available for repairing and restoring communication, communication was established by utilizing parallel wires on each side of the channel and transmitting signals across the space by these electromagnetic waves.

The apparatus (fig. 1) connected to each wire consists of—

(*a*) A rheotome or make and break wheel, causing about 260 undulations per second in the primary wire.

(*b*) An ordinary battery of about 100 Leclanché cells, of the so-called dry and portable form.

(*c*) A Morse telegraph key.

(*d*) A telephone to act as receiver.

(*e*) A switch to start and stop the rheotome.

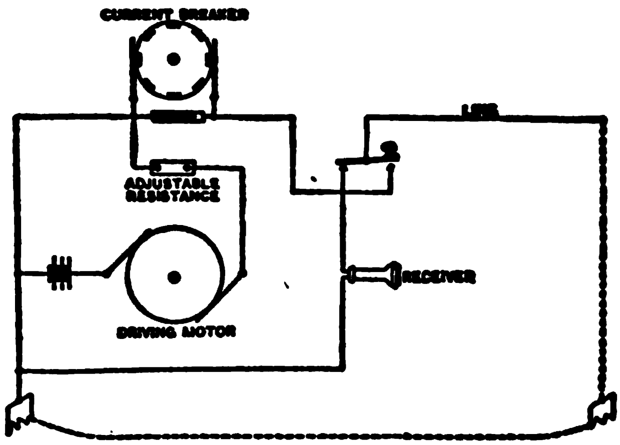

FIG. 1. Diagram of connections of Mr. Preece's system.

Good signals depend more on the rapid rise and fall of the primary current than on the amount of energy thrown into vibration. Leclanché cells gave as good signals at 3.3 miles distant as 2½ horse-power transformed into alternating currents by an alternator, owing to the smooth sinusoidal curves of the latter. Two hundred and sixty vibrations per second give a pleasant note to the ear, easily read when broken up by the key into dots and dashes.

In my electromagnetic system two parallel circuits are established, one on each side of a channel or bank of a river, each circuit becoming successively the primary and secondary of an induction system, according to the direction in which the signals are being sent. Strong alternating or vibrating currents of electricity are transmitted in the first circuit so as to form signals, letters, and words in Morse character. The effects of the rise and fall of these currents are transmitted as electro-

magnetic waves through the intervening space, and if the secondary circuit is so situated as to be washed by these ethereal waves, their energy is transformed into secondary currents in the second circuit, which can be made to affect a telephone and thus to reproduce the signals. Of course their intensity is much reduced, but still their presence has been detected, though five miles of clear space have separated the two circuits.

Such effects have been known scientifically in the laboratory since the days of Faraday and of Henry, but it is only within the last few years that I have been able to utilize them practically through considerable distances. This has been rendered possible through the introduction of the telephone.

Last year (August, 1896) an effort was made to establish communication with the North Sandhead (Goodwin) lightship. The apparatus used was designed and manufactured by Messrs. Evershed and Vignoles, and a most ingenious relay to establish a call invented by Mr. Evershed. One extremity of the cable was coiled in a ring on the bottom of the sea, embracing the whole area over which the lightship swept while swinging to the tide, and the other end was connected with the shore. The ship was surrounded above the water line with another coil. The two coils were separated by a mean distance of about 200 fathoms, but communication was found to be impracticable. The screening effect of the sea water and the effect of the iron hull of the ship absorbed practically all the energy of the currents in the coiled cable, and the effects on board, though perceptible, were very trifling—too minute for signaling. Previous experiments had failed to show the extremely rapid rate at which energy is absorbed with the depth or thickness of sea water. The energy is absorbed in forming eddy currents. There is no difficulty whatever in signaling through 15 fathoms. Speech by telephone has been maintained through 6 fathoms. Although this experiment has failed through water, it is thoroughly practical through air to considerable distances where it is possible to erect wires of similar length to the distance to be crossed on each side of the channel. It is not always possible, however, to do this, nor to get the requisite height to secure the best effect. It is impossible on a lightship and on rock lighthouses. There are many small islands—Sark, for example—where it cannot be done.

In July last Mr. Marconi brought to England a new plan. My plan is based entirely on utilizing electromagnetic waves of very low frequency. It depends essentially on the rise and fall of currents in the primary wire. Mr. Marconi utilizes electric or Hertzian waves of very high frequency, and they depend upon the rise and fall of electric force in a sphere or spheres. He has invented a new relay which, for sensitiveness and delicacy, exceeds all known electric apparatus.

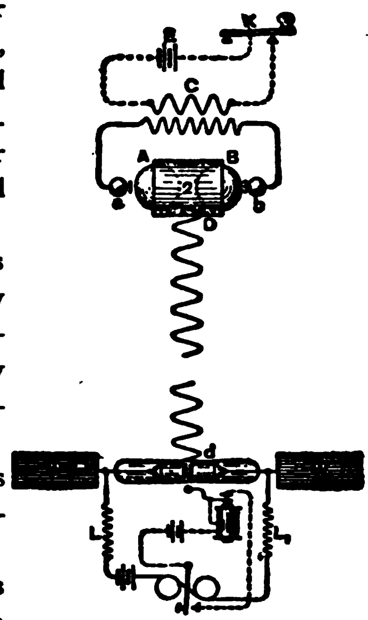

FIG. 2. Diagram of the Marconi apparatus.

The peculiarity of Mr. Marconi's system is that, apart from the ordinary connecting wires of the apparatus, conductors of very moderate length only are needed, and even these can be dispensed with if reflectors are used.

The transmitter.—His transmitter is Professor Righi's form of Hertz radiator (fig. 2).

Two spheres of solid brass, 4 inches in diameter (A and B), are fixed in an oil-tight case D of insulating material, so that a hemisphere of each is exposed, the other hemisphere being immersed in a bath of vaseline oil. The use of oil has several advantages. It maintains the surfaces of the spheres electrically clean, avoiding the frequent polishing required by Hertz's exposed balls. It impresses on the waves excited by these spheres a uniform and constant form. It tends to reduce the wave lengths—Righi's waves are measured in centimeters, while Hertz's were measured in meters. For these reasons the distance at which effects are produced is increased. Mr. Marconi uses generally waves of about 120 centimeters long. Two small spheres, *a* and *b*, are fixed close to the large spheres, and connected each to one end of the secondary circuit of the "induction coil" C, the primary circuit of which is excited by a battery E, thrown in and out of circuit by the Morse key K. Now, whenever the key K is depressed sparks pass between 1, 2, and 3, and since the system A B contains capacity and electric inertia, oscillations are set up in it of extreme rapidity. The line

of propagation is D *d*, and the frequency of oscillation is probably about 250 millions per second.

The distance at which effects are produced with such rapid oscillations depends chiefly on the energy in the discharge that passes. A 6-inch spark coil has sufficed through 1, 2, 3, up to 4 miles, but for greater distances we have used a more powerful coil—one emitting sparks 20 inches long. It may also be pointed out that this distance increases with the diameter of the spheres A and B, and it is nearly doubled by making the spheres solid instead of hollow.

The receiver.—Marconi's relay (fig. 2) consists of a small glass tube 4 centimeters long, into which two silver pole pieces are tightly fitted, separated from each other by about half a millimeter—a thin space which is filled up by a mixture of fine nickel and silver filings, mixed with a trace of mercury. The tube is exhausted to a vacuum of 4 millimeters, and sealed. It forms part of a circuit containing a local cell and a sensitive telegraph relay. In its normal condition the metallic powder is virtually an insulator. The particles lie higgledy-piggledy, anyhow, in disorder. They lightly touch each other in an irregular method, but when electric waves fall upon them they are "polarized," order is installed. They are marshaled in serried ranks, they are subject to pressure—in fact, as Prof. Oliver Lodge expresses it, they "cohere"—electrical contact ensues and a current passes. The resistance of such a space falls from infinity to about 5 ohms. The electric resistance of Marconi's relay—that is, the resistance of the thin disc of loose powder—is practically infinite when it is in its normal or disordered condition. It is then, in fact, an insulator. This resistance drops sometimes to 5 ohms, when the absorption of the electric waves by it is intense. It therefore becomes a conductor. It may be, as suggested by Professor Lodge, that we have in the measurement of the variable resistance of this instrument a means of determining the intensity of the energy falling upon it. This variation is being investigated both as regards the magnitude of the energy and the frequency of the incident waves. Now such electrical effects are well known. In 1866 Mr. S. A. Varley introduced a lightning protector constructed like the above tube, but made of boxwood and containing powdered carbon. It was fixed as a shunt to the instrument to be protected. It acted well, but it was subject to this coherence, which rendered the cure more troublesome than the disease, and its use had to be abandoned. The same action is very common in granulated carbon microphones like

Hunning's, and shaking has to be resorted to to decohere the carbon particles to their normal state. M. E. Branly (1890) showed the effect with copper, aluminum, and iron filings. Prof. Oliver Lodge, who has done more than anyone else in England to illustrate and popularize the work of Hertz and his followers, has given the name "coherer" to this form of apparatus. Marconi "decoheres" by making the local current very rapidly vibrate a small hammer head against the glass tube, which it does effectually, and in doing so makes such a sound that reading Morse characters is easy. The same current that decoheres can also record Morse signals on paper by ink. The exhausted tube has two wings which, by their size, tune the receiver to the transmitter by

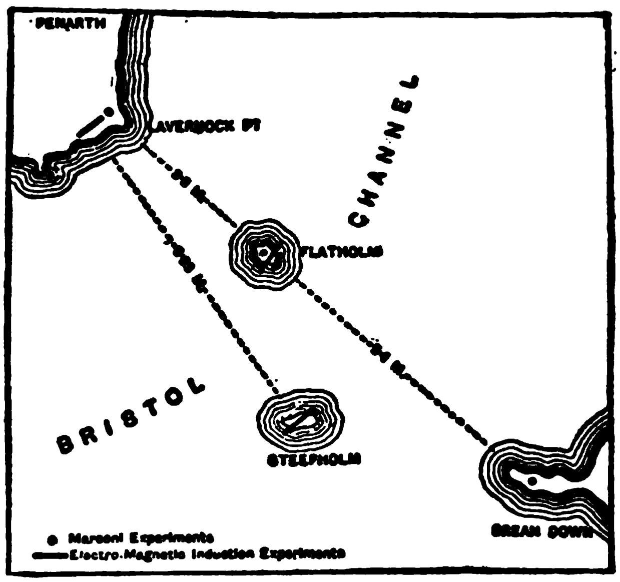

FIG. 3. Map of locality where the experiments were carried out.

varying the capacity of the apparatus. Choking coils prevent the energy escaping. The analogy to Prof. Silvanus Thompson's wave apparatus is evident. Oscillations set up in the transmitter fall upon the receiver tuned in sympathy with it, coherence follows, currents are excited, and signals made.

In open clear spaces within sight of each other nothing more is wanted, but when obstacles intervene and great distances are in question, height is needed—tall masts, kites, and balloons have been used. Excellent signals have been transmitted between Penarth and Brean Down, near Weston-super-Mare, across the Bristol Channel, a distance

of nearly 9 miles (fig. 3). (The system was here shown in operation.)

Mirrors also assist and intensify the effects. They were used in the earlier experiments, but they have been laid aside for the present, for they are not only expensive to make, but they occupy much time in manufacture.

It is curious that hills and apparent obstructions fail to obstruct. The reason is probably the fact that the lines of force escape these hills. When the ether is entangled in matter of different degrees of inductivity, the lines are curved, as in fact they are in light. Figure 4 shows how a hill is virtually bridged over by these lines, and consequently some electric waves fall on the relay. Weather seems to have no influence; rain, fogs, snow, and wind avail nothing.

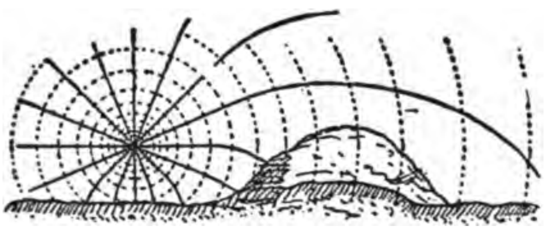

FIG. 4. Diagram illustrating the way in which hills are bridged by the electric waves.

The wings shown in figure 2 may be removed. One pole can be connected with earth, and the other extended up to the top of the mast, or fastened to a balloon by means of a wire. The wire and balloon or kite, covered with tin foil, becomes the wing. In this case one pole of the transmitter must also be connected with earth. This is shown in figure 5.

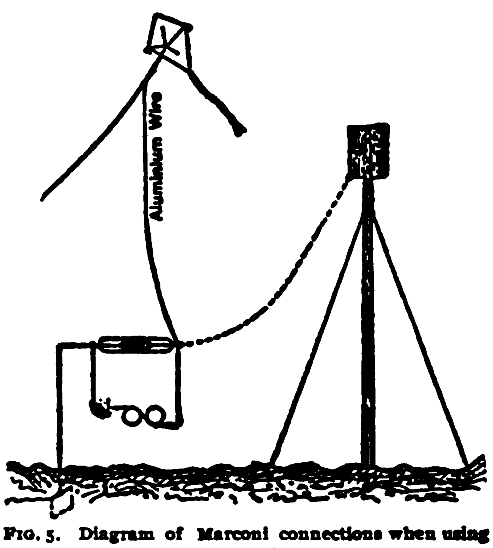

FIG. 5. Diagram of Marconi connections when using pole or kite.

There are some apparent anomalies that have developed themselves during the experiments. Mr. Marconi finds that his relay acts even when it is placed in a perfectly c l o s e d metallic box. This is the fact that has given rise to the rumor that he can blow up an ironclad ship. This might be true if he could plant his properly tuned receiver in the magazine of an enemy's ship. Many other funny things could be done if this were possible. I remember in my childhood that Captain Warner blew up a ship

at a great distance off Brighton. How this was done was never known, for his secret died shortly afterwards with him. It certainly was not by means of Marconi's relay.

The distance to which signals have been sent is remarkable. On Salisbury Plain Mr. Marconi covered a distance of 4 miles. In the Bristol Channel this has been extended to over 8 miles, and we have by no means reached the limit. It is interesting to read the surmises of others. Half a mile was the wildest dream.

It is easy to transmit many messages in any direction at the same time. It is only necessary to tune the transmitters and receivers to the same frequency or "note." I could show this here, but we are bothered by reflection from the walls. This does not happen in open space. Tuning is very easy. It is simply necessary to vary the capacity of the receiver, and this is done by increasing the length of the wings W in figure 2. The proper length is found experimentally close to the transmitter. It is practically impossible to do so far away.

It has been said that Mr. Marconi has done nothing new. He has not discovered any new rays; his transmitter is comparatively old; his receiver is based on Branly's coherer. Columbus did not invent the egg, but he showed how to make it stand on its end, and Marconi has produced from known means a new electric eye, more delicate than any known electrical instrument, and a new system of telegraphy that will reach places hitherto inaccessible. There are a great many practical points connected with this system that require to be threshed out in a practical manner before it can be placed on the market, but enough has been done to prove its value, and to show that for shipping and light-house purposes it will be a great and valuable acquisition.

CHEMISTRY

In 1864 NEWLANDS of London and Lothar Meyer of Germany found that if many of the elements were arranged in order of their atomic weights, certain resemblances in their qualities were noticeable between an element and the eighth from it. This became known as the theory of chemical octaves. In 1869 Mendeléef made out a new list, reconsidered the resemblances, and left blanks here and there to be filled in with elements still to be discovered. Now the most striking proof of the theory is that elements have actually been discovered answering the description given them and with the proper atomic weights. In his table the elements, arranged in order of their atomic weights, fall naturally into families. The great significance of this theory is that the elements are not wholly independent, but would seem themselves to be compound, with qualities depending on their atomic weights. The large number of new elements recently discovered all find a more or less satisfactory place in the periodic table.

Another conception that is having great influence is that of the charged atom or "ion." Putting together the observations of a number of chemists, von t'Hoff has announced the law that if a substance is dissolved in a large quantity of the solvent the molecules are so far separated as to act as in a gas. Thus they exert pressure on the interior walls of the receptacle. Exceptions to this rule he showed to take place when the atoms of the molecules are electrically dissociated, that is, become charged atoms or "ions." A solution of potassium nitrate is such a charged solution. If an electric current is sent through it, the minus atoms of potassium are attracted to the plus pole, the plus atoms of

nitrate NO_3 are drawn to the minus pole. Both sets of atoms are discharged. They then become free to act on the water of the solution. The potassium combines with the oxygen of the water and liberates hydrogen; the NO_3 groups combine with the hydrogen of the water and liberate oxygen. This is in general the best explanation of the method of electrolysis.

Doctor Jaques Loeb has shown that such charged salt atoms cause muscular vibrations. A heart will begin beating if placed in such a solution. The electric charge contained by such atoms in solution seems to be enormous. Their influence on life is still a question of study. Dr. Loeb thinks he has been able to start a growth in the unfertilized eggs of sea urchins. It may be, however, that a cross is not always needed between such eggs. Some poisons are shown to contain strong minus ions. Food may even be needed more for its ions than the heat it contains. It is conceivable that a nerve impulse is based on the same principle. The nerves consist of phosphorized fat in a weak salt solution. They are "colloid" substances, that is, they do not crystallize when they solidify. The nerve impulse may be some sort of precipitation along the nerve, each colloid releasing some minus charged ions which precipitate the next colloid. The last minus ions act on and contract the muscle. But this is still in the domain of unproved theory.

Equally unproved is Lord Kelvin's theory that the atom is a whirling ring in the ether, comparable to a ring of smoke in the air. Such a ring would account for many qualities of the atoms, such as indestructibility, but, as Lord Kelvin himself has said, the hypothesis is as yet only a dream.

D. I. MENDELEEF

Dmitri Ivanovich Mendeleef was born at Tobolsk, Russia, in 1834. He was made professor of chemistry in St. Petersburg in 1866. In 1869 he took up the question of Newland's law of octaves in chemistry and announced his great law of the periodicity of the elements. This is in brief that the qualities of the elements bear a close relation to their atomic weights. If the elements are arranged in a series

THE PERIODICITY OF THE ELEMENTS

The Elements	Symbols and Atomic Weights		The Composition of the Saline Oxides *= oxide is acid. †= oxide is basic.	Small Periods or Series
	E	A	E_2O_n	
	[6]		[7]	[11]
Hydrogen	H	1	1 = n	1
Lithium	Li	7	1†	2
Beryllium	Be	9	— 2	
Boron	B	11	— — 3	
Carbon	C	12	— — — 4	
Nitrogen	N	14	1 — 3* — 5*	
Oxygen	O	16		
Fluorine	F	19		
Sodium	Na	23	1†	3
Magnesium	Mg	24	— 2†	
Aluminium	Al	27	— — 3	
Silicon	Si	28	— — 3 4	
Phosphorus	P	31	1 — 3* 4* 5*	
Sulphur	S	32	— 2 — 4* 5* 6*	
Chlorine	Cl	35½	1 — 3 — 5* — 7*	
Potassium	K	39	1†	4
Calcium	Ca	40	— 2†	
Scandium	Sc	44	— — 3†	
Titanium	Ti	48	— — 3 4	
Vanadium	V	51	— 2 3 4 5	
Chromium	Cr	52	— 2 3 — — 6*	
Manganese	Mn	55	— 2† 3 4 — 6* 7*	
Iron	Fe	56	— 2† 3 — — 6*	
Cobalt	Co	58½	— 2† 3 4	
Nickel	Ni	59	— 2† 3	
Copper	Cu	63	1† 2†	5
Zinc	Zn	65	— 2†	
Gallium	Ga	70	— — 3	
Germanium	Ge	72	— 2 — 4	
Arsenic	As	75	— — 3 — 5*	
Selenium	Se	79	— — — 4 — 6*	
Bromine	Br	80	1 — — — 5* — 7*	
Rubidium	Rb	85	1†	6
Strontium	Sr	87	— 2†	
Yttrium	Y	89	— — 3†	
Zirconium	Zr	90	— — — 4	
Niobium	Nb	94	— — 3 — 5*	
Molybdenum	Mo	96	— 2 3 4 — 6*	
	(1)			
Ruthenium	Ru	103	— 2 3 4 — 6 — 8	
Rhodium	Rh	104	— 2 3 4 — 6	
Palladium	Pd	106	1† 2 — 4	
Silver	Ag	108	1†	7
Cadmium	Cd	112	— 2†	
Indium	In	113	— 2 3	
Tin	Sn	118	— 2 — 4	
Antimony	Sb	120	— — 3 4 5	8
Tellurium	Te	125	— — — 4 — 6*	
Iodine	I	127	1 — 3 — 5* — 7*	
Cæsium	Cs	133	1†	
Barium	Ba	137	— 2†	
Lanthanum	La	138	— — 3†	
Cerium	Ce	140	— — 3 4	
Didymium	Di	142	— — 3 — 5	
	(14)			
Ytterbium	Yb	173	— — 3	10
	(1)			
Tantalum	Ta	182	— — — — 5	
Tungsten	W	184	— — — 4 — 6	
	(1)			
Osmium	Os	191	— — 3 4 — 6 — 8	
Iridium	Ir	193	— — 3 4 — 6	
Platinum	Pt	196	— 2 — 4	
Gold	Au	198	1 — 3	11
Mercury	Hg	200	1† 2†	
Thallium	Tl	204	1† — 3	
Lead	Pb	206	— 2† — 4	
Bismuth	Bi	208	— — 3 — 5	
	(5)			
Thorium	Th	232	— — — 4	12
	(1)			
Uranium	U	240	— — — 4 — 6	

according to their atomic weights, the list seems naturally to break into families of related elements. This enabled Mendeléef to correct many of the atomic weights then accepted, and, what is most convincing, to describe closely hitherto undiscovered elements needed to fill out certain families, which afterward turned up with qualities tallying wonderfully with his descriptions.

THE PERIODIC LAW OF THE CHEMICAL ELEMENTS

The high honour bestowed by the Chemical Society in inviting me to pay a tribute to the world-famed name of Faraday by delivering this lecture has induced me to take for its subject the Periodic Law of the Elements—this being a generalization in chemistry which has of late attracted much attention.

While science is pursuing a steady and onward movement, it is convenient from time to time to cast a glance back on the route already traversed, and especially to consider the new conceptions which aim at discovering the general meaning of the stock of facts accumulated from day to day in our laboratories. Owing to the possession of laboratories, modern science now bears a new character, quite unknown, not only to antiquity, but even to the preceding century. Bacon's and Descartes' idea of submitting the mechanism of science simultaneously to experiment and reasoning has been fully realized in the case of chemistry, it having not only been possible but always customary to experiment. Under the all-penetrating control of experiment, a new theory, even if crude, is quickly strengthened, provided it be founded on a sufficient basis; the asperities are removed, it is amended by degrees, and soon loses the phantom light of a shadowy form or of one founded on mere prejudice; it is able to lead to logical conclusions, and to submit to experimental proof. Willingly or not, in science we all must submit not to do what seems to us attractive from one point of view or from another, but to what represents an agreement between theory and experiment. Is it long since many refused to accept the generalizations involved in the law of Avogadro and Ampère, so widely extended by Gerhardt? We still may hear the voices of its opponents; they enjoy perfect freedom, but vainly will their voices rise so long as they do not use the language of demonstrated facts. The striking observations with the spectroscope which have permitted us to analyze the chemical constitu-

tion of distant worlds, seemed at first applicable to the task of determining the nature of the atoms themselves; but the working out of the idea in the laboratory soon demonstrated that the characters of spectra are determined, not directly by the atoms, but by the molecules into which the atoms are packed; and so it became evident that more verified facts must be collected before it will be possible to formulate new generalizations capable of taking their place beside those ordinary ones based upon the conception of simple substances and atoms. But as the shade of the leaves and roots of living plants, together with the relics of a decayed vegetation, favour the growth of the seedling and serve to promote its luxurious development, in like manner sound generalizations—together with the relics of those which have proved to be untenable—promote scientific productivity, and insure the luxurious growth of science under the influence of rays emanating from the centers of scientific energy. Such centers are scientific associations and societies. Before one of the oldest and most powerful of these I am about to take the liberty of passing in review the twenty years' life of a generalization which is known under the name of periodic law. It was in March, 1869, that I ventured to lay before the then youthful Russian Chemical Society the ideas upon the same subject which I had expressed in my just written "Principles of Chemistry."

Without entering into details, I will give the conclusions I then arrived at in the very words I used:—

1. The elements, if arranged according to their atomic weights, exhibit an evident *periodicity* of properties.

2. Elements which are similar as regards their chemical properties have atomic weights which are either of nearly the same value (*e. g.*, platinum, iridium, osmium) or which increase regularly (*e. g.*, potassium, rubidium, cæsium).

3. The arrangement of the elements, or of groups of elements, in the order of their atomic weights, corresponds to their so-called *valencies*, as well as, to some extent, to their distinctive chemical properties—as is apparent, among other series, in that of lithium, beryllium, barium, carbon, nitrogen, oxygen, and iron.

4. The elements which are the most widely diffused have small atomic weights.

5. The magnitude of the atomic weight determines the character of the element, just as the magnitude of the molecule determines the character of a compound.

6. We must expect the discovery of many yet unknown elements—for example, elements analogous to aluminum and silicon, whose atomic weight would be between 65 and 75.

7. The atomic weight of an element may sometimes be amended by a knowledge of those of the contiguous elements. Thus, the atomic weight of tellurium must lie between 123 and 126, and cannot be 128.

8. Certain characteristic properties of the elements can be foretold from their atomic weights.

The aim of this communication will be fully attained if I succeed in drawing the attention of investigators to those relations which exist between the atomic weights of dissimilar elements, which, so far as I know, have hitherto been almost completely neglected. I believe that the solution of some of the most important problems of our science lies in researches of this kind.

To-day, twenty years after the above conclusions were formulated, they may still be considered as expressing the essence of the now well known periodic law.

Reverting to the epoch terminating with the sixties, it is proper to indicate three series of data without the knowledge of which the periodic law could not have been discovered, and which rendered its appearance natural and intelligible.

In the first place, it was at that time that the numerical value of atomic weights became definitely known. Ten years earlier such knowledge did not exist, as may be gathered from the fact that in 1860 chemists from all parts of the world met at Karlsruhe in order to come to some agreements, if not with respect to views relating to atoms, at any rate as regards their definite representation. Many of those present probably remember how vain were the hopes of coming to an understanding, and how much ground was gained at that congress by the followers of the unitary theory so brilliantly represented by Cannizzaro. I vividly remember the impression produced by his speeches, which admitted of no compromise, and seemed to advocate truth itself, based on the conceptions of Avogadro, Gerhardt, and Regnault, which at that time were far from being generally recognized. And though no understanding could be arrived at, yet the objects of the meeting were attained, for the ideas of Cannizzaro proved, after a few years, to be the only ones which could stand criticism, and which represented an atom as—"the smallest portion of an element which enters into a mole-

cule of its compound." Only such real atomic weights—not conventional ones—could afford a basis for generalization. It is sufficient, by way of example, to indicate the following cases in which the relation is seen at once and is perfectly clear:

K =39	Rb=85	Cs=133
Ca=40	Sr=87	Ba=137

whereas with the equivalents then in use—

K =39	Rb=85	Cs=133
Ca=20	Sr=43.5	Ba=68.5

the consecutiveness of change in atomic weight, which with the true values is so evident, completely disappears.

Secondly, it had become evident during the period 1860-70, and even during the preceding decade, that the relations between the atomic weights of analogous elements were governed by some general and simple laws. Cooke, Cremers, Gladstone, Gmelin, Lenssen, Pettenkofer, and especially Dumas, had already established many facts bearing on that view. Thus Dumas compared the following groups of analogous elements with organic radicles—

	Diff.		Diff.		Diff.		Diff.
Li = 7		Mg=12		P = 31		O = 8	
	—16		—8		—44		—8
Na=23		Ca =20		As= 75		S =16	
	—16		—3×8		—44		—3×8
K =39		Sr =44		Sb=119		Se =40	
			—3×8		—2×44		—3×8
		Ba =68		Bi =207		Te=64	

and pointed out some really striking relationships, such as the following

F=19.

Cl=35.5=19+16.5

Br=80=19+2×16.5+28

I=127=2×19+2×16.5+2×.28.

A. Strecker, in his work, "*Theorien und Experimente zur Bestimmung der Atomgewichte der Elemente*" (Braunschweig, 1859), after summarizing the data relating to the subject, and pointing out the remarkable series of equivalents—

Cr=26.2 Mn=27.6 Fe=28 Ni=29 Co=30 Cu=31.7 Zn=32.5

remarks that: It is hardly probable that all the above-mentioned relations between the atomic weights (or equivalents) of chemically analogous elements are merely accidental. We must, however, leave to the

future the discovery of the *law* of the relations which appears in these figures.

In such attempts at arrangement and in such views are to be recognized the real forerunners of the periodic law; the ground was prepared for it between 1860 and 1870, and that it was not expressed in a determinate form before the end of the decade may, I suppose, be ascribed to the fact that only analogous elements had been compared. The idea of seeking for a relation between the atomic weights of all the elements was foreign to the ideas then current, so that neither the *vis tellurique* of De Chancourtois, nor the law of octaves of Newlands like Dumas and Strecker, more than Lenssen and Pettenkofer, had made an approach to the periodic law and had discovered its germs. The solution of the problem advanced but slowly, because the facts, but not the law, stood foremost in all attempts; and the law could not awaken a general interest so long as elements, having no apparent connection with each other, were included in the same octave, as, for example:—

1st octave of Newlands, H, F, Cl, Co & Ni, Br, Pd, I, Pt & Ir.

7th ditto, O, S, Fe, Se, Rh & Ru, Te, Au, Os or Th.

Analogies of the above order seemed quite accidental, and the more so as the octave contained occasionally ten elements instead of eight, and when two such elements as Ba and V, Co and Ni, or Rh and Ru, occupied one place in the octave. Nevertheless the fruit was ripening, and I now see clearly that Strecker, De Chancourtois, and Newlands stood foremost in the way towards the discovery of the periodic law, and that they merely wanted the boldness necessary to place the whole question at such a height that its reflection on the facts could be clearly seen.

A third circumstance which revealed the periodicity of chemical elements was the accumulation, by the end of the sixties, of new information respecting the rare elements, disclosing their many-sided relations to the other elements and to each other. The researches of Marignac on niobium, and those of Roscoe on vanadium, were of special moment. The striking analogies between vanadium and phosphorus on the one hand, and between vanadium and chromium on the other, which are so apparent in the investigations connected with that element, naturally induced the comparison of V=51 with Cr=52, Nb=94 with Mo=96, Ta=192 with W=194; while, on the other hand, P=31 could be compared with S=32, As=75 with Se=79, and Sb=120 with Te=125. From such approximations there remained but one step to the discovery of the law of periodicity.

The law of periodicity was thus a direct outcome of the stock of generalizations and established facts which had accumulated by the end of the decade 1860-70: it is an embodiment of those data in a more or less systematic expression. Where, then, lies the secret of the special importance which has since been attached to the periodic law, and has raised it to the position of a generalization which has already given to chemistry unexpected aid, and which promises to be far more fruitful in the future and to impress upon several branches of chemical research a peculiar and original stamp? The remaining part of my communication will be an attempt to answer this question.

In the first place, we have the circumstance that, as soon as the law made its appearance, it demanded a revision of many facts which were considered by chemists as fully established by existing experience. I shall return later on, briefly to this subject, but I wish now to remind you that the periodic law, by insisting on the necessity for a revision of supposed facts, exposed itself at once to destruction in its very origin. Its first requirements, however, have been almost entirely satisfied during the last twenty years; the supposed facts have yielded to the law, thus proving that the law itself was a legitimate induction from the verified facts. But our inductions from data have often to do with such details of a science so rich in facts, that only generalizations which cover a wide range of important phenomena can attract general attention. What were the regions touched on by the periodic law? This is what we shall now consider.

The most important point to notice is, that periodic functions, used for the purpose of expressing changes which are dependent on variations of time and space, have been long known. They are familiar to the mind when we have to deal with motion in closed cycles, or with any kind of deviation from a stable position, such as occurs in pendulum oscillations. A like periodic function became evident in the case of the elements, depending on the mass of the atom. The primary conception of the masses of bodies, or of the masses of atoms, belongs to a category which the present state of science forbids us to discuss, because as yet we have no means of dissecting or analyzing the conception. All that was known of functions dependent on masses derived its origin from Galileo and Newton, and indicated that such functions either increase or decrease with the increase of mass, like the attraction of celestial bodies. The numerical expression of the phenomena was always found to be proportional to the mass, and in no case was an increase of mass

followed by a recurrence of properties such as is disclosed by the periodic law of the elements. This constituted such a novelty in the study of the phenomena of nature that, although it did not lift the veil which conceals the true conception of mass, it nevertheless indicated that the explanation of that conception must be searched for in the masses of the atoms; the more so, as all masses are nothing but aggregations, or additions of chemical atoms which would be best described as chemical individuals. Let me remark, by the way, that though the Latin word "*individual*" is merely a translation of the Greek word "*atom,*" nevertheless history and custom have drawn a sharp distinction between the two words, and the present chemical conception of atoms is nearer to that defined by the Latin word than by the Greek, although this latter also has acquired a special meaning which was unknown to the classics. The periodic law has shown that our chemical individuals display a harmonic periodicity of properties dependent on their masses. Now natural science has long been accustomed to deal with periodicities observed in nature, to seize them with the vise of mathematical analysis, to submit them to the rasp of experiment. And these instruments of scientific thought would surely long since have mastered the problem connected with the chemical elements, were it not for a new feature which was brought to light by the periodic law and which gave a peculiar and original character to the periodic function.

If we mark on an axis of abscissæ a series of lengths proportional to angles, and trace ordinates which are proportional to sines or other trigonometrical functions, we get periodic curves of a harmonic character. So it might seem, at first sight, that with the increase of atomic weights the function of the properties of the elements should also vary in the same harmonious way. But in this case there is no such continuous change as in the curves just referred to, because the periods do not contain the infinite number of points constituting a curve, but a *finite* number only of such points. An example will better illustrate this view. The atomic weights—

Ag=108 Cd=112 In=113 Sn=118 Sb=120
Te=125 I=127

steadily increase, and their increase is accompanied by a modification of many properties, which constitutes the essence of the periodic law. Thus, for example, the densities of the above elements decrease steadily, being respectively—

10.5 8.6 7.4 7.2 6.7 6.4 4.9

while their oxides contain an increasing quantity of oxygen—

Ag_2O Cd_2O_2 In_2O_3 Sn_2O_4 Sb_2O_5 Te_2O_6 I_2O_7

But to connect by a curve the summits of the ordinates expressing any of these properties would involve the rejection of Dalton's law of multiple proportions. Not only are there no intermediate elements between silver, which gives AgCl, and cadmium, which gives $CdCl_2$, but according to the very essence of the periodic law, there can be none: in fact a uniform curve would be inapplicable in such a case, as it would lead us to expect elements possessed of special properties at any point of the curve. The periods of the elements have thus a character very different from those which are so simply represented by geometers. They correspond to points, to numbers, to sudden changes destitute of intermediate steps or positions, in the absence of elements intermediate between, say silver and cadmium, or aluminum and silicon, we must recognize a problem to which no direct application of the analysis of the infinitely small can be made. Therefore, neither the trigonometrical functions proposed by Ridberg and Flavitzky, nor the pendulum oscillations suggested by Crookes, nor the cubical curves of the Rev. Mr. Haughton, which have been proposed for expressing the periodic law, from the nature of the case, can represent the periods of the chemical elements. If geometrical analysis is to be applied to this subject, it will require to be modified in a special manner. It must find the means of representing in a special way, not only such long periods, as that comprising—

K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br,

but short periods like the following:—

Na Mg Al Si P S Cl.

In the theory of numbers only do we find problems analogous to ours, and two attempts at expressing the atomic weights of the elements by algebraic formulæ seem to be deserving of attention, although none of them can be considered as a complete theory, nor as promising finally to solve the problem of the periodic law. The attempt of E. J. Mills (1886) does not even aspire to attain this end. He considers that all atomic weights can be expressed by a logarithmic function,

$$15\,(n-0.9375^t),$$

in which the variables n and t are whole numbers. Thus, for oxygen, $n=2$, and $t=1$, whence its atomic weight is $=15.94$; in the case of chlorine, bromine, and iodine, n has respective values of 3, 6, and 9,

whilst t=7, 6, and 9; in the case of potassium, rubidium, and cæsium, n=4, 6, and 9, and t=14, 18, and 20.

Another attempt was made in 1888 by B. N. Tchitchérin. Its author places the problem of the periodic law in the first rank, but as yet he has investigated the alkali metals only. Tchitchérin first noticed the simple relations existing between the atomic volumes of all alkali metals; they can be expressed, according to his views, by the formula

$$A(2-0.00535An),$$

where A is the atomic weight, and n is equal to 8 for lithium and sodium, to 4 for potassium, to 3 for rubidium, and to 2 for cæsium. If n remained equal to 8 during the increase of A, the volume would become zero at A=46 2-3, and it would reach its maximum at A=23 1-3. The close approximation of the number 46 2-3 to the differences between the atomic weights of analogous elements (such as Cs-Rb, I-Br, and so on); the close correspondence of the number 23 1-3 to the atomic weight of sodium; the fact of n being necessarily a whole number, and several other aspects of the question, induce Tchitchérin to believe that they afford a clue to the understanding of the nature of the elements; we must, however, await the full development of his theory before pronouncing judgment on it. What we can at present only be certain of is this: that attempts like the two above named must be repeated and multiplied, because the periodic law has clearly shown that the masses of the atoms increase abruptly, by steps, which are clearly connected in some way to Dalton's law of multiple proportions; and because the periodicity of the elements finds expression in the transition from RX to RX_2, RX_3, RX_4, and so on till RX_8, at which point, the energy of the combining forces being exhausted, the series begins anew from RX to RX_2, and so on.

While connecting by new bonds the theory of the chemical elements with Dalton's theory of multiple proportions, or atomic structure of bodies, the periodic law opened for natural philosophy a new and wide field for speculation. Kant said that there are in the world "two things which never cease to call for the admiration and reverence of man: the moral law within ourselves, and the stellar sky above us. But when we turn our thoughts towards the nature of the elements and the periodic law, we must add a third subject, namely, "the nature of the elementary individuals which we discover everywhere around us." Without them the stellar sky itself is inconceivable; and in the atoms we see at once their peculiar individualities, the infinite multiplicity of the

individuals, and the submission of their seeming freedom to the general harmony of nature.

Having thus indicated a new mystery of nature, which does not yet yield to rational conception, the periodic law, together with the revelations of spectrum analysis, have contributed to again revive an old but remarkably long-lived hope—that of discovering, if not by experiment, at least by a mental effort, the *primary matter*—which had its genesis in the minds of the Grecian philosophers, and has been transmitted, together with many other ideas of the classic period, to the heirs of their civilization. Having grown, during the times of the alchemists up to the period when experimental proof was required, the idea has rendered good service; it induced those careful observations and experiments which later on called into being the works of Scheele, Lavoisier, Priestley, and Cavendish. It then slumbered awhile, but was soon awakened by the attempts either to confirm or to refute the ideas of Prout as to the multiple proportion relationship of the atomic weights of all the elements. And once again the inductive or experimental method of studying Nature gained a direct advantage from the old Pythagorean idea: because atomic weights were determined with an accuracy formerly unknown. But again the idea could not stand the ordeal of experimental test, yet the prejudice remains and has not been uprooted, even by Stas; nay, it has gained new vigor, for we see that all which is imperfectly worked out, new and unexplained, from the still scarcely studied rare metals to the hardly perceptible nebulæ, have been used to justify it. As soon as spectrum analysis appears as a new and powerful weapon of chemistry, the idea of a primary matter is immediately attached to it. From all sides we see attempts to constitute the imaginary substance helium, the so much longed for primary matter. No attention is paid to the circumstance that the helium line is only seen in the spectrum of the solar protuberances, so that its universality in Nature remains as problematic as the primary matter itself; nor to the fact that the helium line is wanting amongst the Fraunhofer lines of the solar spectrum, and thus does not answer to the brilliant fundamental conception which gives its real force to spectrum analysis.

And finally, no notice is even taken of the indubitable fact that the brilliancies of the spectral lines of the simple substances vary under different temperatures and pressures; so that all probabilities are in favor of the helium line simply belonging to some long since known element placed under such conditions of temperature, pressure, and gravity as

have not yet been realized in our experiments. Again, the idea that the excellent investigations of Lockyer of the spectrum of iron can be interpreted in favor of the compound nature of that element, evidently must have arisen from some misunderstanding. The spectrum of a compound certainly does not appear as a sum of the spectra of its components; and therefore the observations of Lockyer can be considered precisely as a proof that iron undergoes no other changes at the temperature of the sun than those which it experiences in the voltaic arc—provided the spectrum of iron is preserved. As to the shifting of some of the lines of the spectrum of iron while the other lines maintain their positions, it can be explained, as shown by M. Kleiber (Journal of the Russian Chemical and Physical Society, 1885, 147) by the relative motion of the various strata of the sun's atmosphere, and by Zöllner's laws of the relative brilliancies of different lines of the spectrum. Moreover, it ought not to be forgotten that if iron were really proved to consist of two or more unknown elements, we should have an increase in the number of our elements—not a reduction, and still less a reduction of all of them to one single primary matter.

Feeling that spectrum analysis will not yield a support to the Pythagorean conception, its modern promoters are so bent upon its being confirmed by the periodic law, that the illustrious Berthellot, in his work, "*Les Origines de l'Alchimie,*" 1885, 313, has simply mixed up the fundamental idea of the law of periodicity with the ideas of Prout, the alchemists, and Democritus about primary matter. But the periodic law, based as it is on the solid and wholesome ground of experimental research, has been evolved independently of any conception as to the nature of the elements; it does not in the least originate in the idea of a unique matter, and it has no historical connection with that relic of the torments of classical thought, and therefore it affords no more indication of the unity of matter or of the compound character of our elements, than the law of Avogadro, or the law of specific heats, or even the conclusions of spectrum analysis. None of the advocates of a unique matter have ever tried to explain the law from the standpoint of ideas taken from a remote antiquity when it was found convenient to admit the existence of many gods—and of a unique matter.

When we try to explain the origin of the idea of a unique primary matter, we easily trace that in the absence of inductions from experiment it derives its origin from the scientifically philosophical attempt at discovering some kind of unity in the immense diversity of individualities

which we see around. In classical times such a tendency could only be satisfied by conceptions about the immaterial world. As to the material world, our ancestors were compelled to resort to some hypothesis, and they adopted the idea of unity in the formative material, because they were not able to evolve the conception of any other possible unity in order to connect the multifarious relations of matter. Responding to the same legitimate scientific tendency, natural science has discovered throughout the universe a unity of plan, a unity of forces, and the convincing conclusions of modern science compel everyone to admit these kinds of unity. But while we admit unity in many things, we none the less must also explain the individuality and the apparent diversity which we cannot fail to trace everywhere. It has been said of old, "Give us a fulcrum, and it will become easy to displace the earth." So also we must say, "Give us something that is individualised, and the apparent diversity will be easily understood." Otherwise, how could unity result in a multitude?

After a long and painstaking research, natural science has discovered the individualities of the chemical elements, and therefore it is now capable not only of analysing, but also of synthesising: it can understand and grasp generality and unity, as well as the individualised and the multifarious. The general and universal, like time and space, like force and motion, vary uniformly; the uniform admit of interpolations, revealing every intermediate phase. But the multitudinous, the individualized—such as ourselves, or the chemical elements, or the members of a peculiar periodic function of the elements, or Dalton's multiple proportions—is characterized in another way: we see in it, side; by side with a connecting general principle, leaps, breaks of continuity, points which escape from the analysis of the infinitely small—an absence of complete intermediate links. Chemistry has found an answer to the question as to the causes of multitudes; and while retaining the conception of many elements, all submitted to the discipline of a general law, it offers an escape from the Indian Nirvana—the absorption in the universal, replacing it by the individualised. However, the place for individuality is so limited by the all-grasping, all-powerful universal, that it is merely a point of support for the understanding of multitude in unity.

Having touched upon the metaphysical bases of the conception of a unique matter which is supposed to enter into the composition of all bodies, I think it necessary to dwell upon another theory, akin to the

above conception-theory of the compound character of the elements now admitted by some—and especially upon one particular circumstance which, being related to the periodic law, is considered to be an argument in favour of that hypothesis.

Dr. Pelopidas, in 1883, made a communication to the Russian Chemical and Physical Society on the periodicity of the hydrocarbon radicles, pointing out the remarkable parallelism which was to be noticed in the change of properties of hydrocarbon radicles and elements when classed in groups. Professor Carnelley, in 1886, developed a similar parallelism. The idea of M. Pelopidas will be easily understood if we consider the series of hydrocarbon radicles which contain, say, 6 atoms of carbon:—

I.	II.	III.	IV.	V.	VI.	VII.	VIII.
C_6H_{13}	C_6H_{12}	C_6H_{11}	C_6H_{10}	C_6H_9	C_6H_8	C_6H_7	C_6H_6

The first of these radicles, like the elements of the first group, combines with Cl, OH, and so on, and gives the derivatives of hexyl alcohol, C_6H_{13} (OH); but, in proportion as the number of hydrogen atoms decreases, the capacity of the radicles, of combining with, say, the halogens, increases. C_6H_{12} already combines with 2 atoms of chlorine; C_6H_{11} with 3 atoms, and so on. The last members of the series comprise the radicles of acids: thus C_6H_8, which belongs to the sixth group, gives, like sulphur, a bibasic acid, $C_6H_8O_2$ $(OH)_2$, which is homologous with oxalic acid. The parallelism can be traced still further, because C_6H_5 appears as a monovalent radicle of benzine, and with it begins a new series of aromatic derivatives, so analogous to the derivatives of the fat series. Let me also mention another example from among those which have been given by M. Pelopidas. Starting from the alkaline radicle of monomethylammonium, $N(CH_3)H_3$, or NCH_6, which presents many analogies with the alkaline metals of the first group, he arrives, by successively diminishing the number of atoms of hydrogen, at a 7th group which contains cyanogen, Cn, which has long since been compared to the halogens of the seventh group.

The most important consequence which, in my opinion, can be drawn from the above comparison is that the periodic law, so apparent in the elements, has a wider application than might appear at first sight; it opens up a new vista of chemical evolutions. But, while admitting the fullest parallelism between the periodicity of the elements and that of the compound radicles, we must not forget that in the periods of the hydrocarbon radicles we have a *decrease* of mass as we pass from the

representatives of the first group to the next, while in the periods of the elements the mass *increases* during the progression. It thus becomes evident that we cannot speak of an identity of periodicity in both cases, unless we put aside the ideas of mass and attraction, which are the real corner-stones of the whole of natural science, and even enter into those very conceptions of simple substances which came to light a full hundred years later than the immortal principles of Newton.

From the foregoing, as well as from the failures of so many attempts at finding in experiment and speculation a proof of the compound character of the elements and of the existence of primordial matter, it is evident, in my opinion, that this theory must be classed among mere utopias. But utopias can only be combated by freedom of opinion, by experiment, and by new utopias. In the republic of scientific theories freedom of opinions is guaranteed. It is precisely that freedom which permits me to criticise openly the widely-diffused idea as to the unity of matter in the elements. Experiments and attempts at confirming that idea have been so numerous that it really would be instructive to have them all collected together, if only to serve as a warning against the repetition of old failures. And now as to new utopias which may be helpful in the struggle against the old ones, I do not think it quite useless to mention a phantasy of one of my students who imagined that the weight of bodies does not depend upon their mass, but upon the character of the motion of their atoms. The atoms, according to this new utopian, may all be homogeneous or heterogeneous, we know not which; we know them in motion only, and that motion they maintain with the persistence as the stellar bodies maintain theirs. The weights of atoms differ only in consequence of their various modes and quantity of motion; the heaviest atoms may be much simpler than an atom of hydrogen—the manner in which it moves causes it to be heavier. My interlocutor even suggested that the view which attributes the greater complexity to the lighter elements finds confirmation in the fact that the hydrocarbon radicles mentioned by Pelopidas, while becoming lighter as they lose hydrogen, change their properties periodically in the same manner as the elements change theirs, according as the atoms grow heavier.

The French proverb, *La critique est facile, mais l'art est difficile,* however, may well be reversed in the case of all such ideal views, as it is much easier to formulate than to criticise them. Arising from the virgin soil of newly-established facts, the knowledge relating to the

elements, to their masses, and to the periodic changes of their properties has given a motive for the formation of utopian hypotheses, probably because they could not be foreseen by the aid of any of the various metaphysical systems, and exist, like the idea of gravitation, as an independent outcome of natural science, requiring the acknowledgment of general laws, when these have been established with the same degree of persistency as is indispensable for the acceptance of a thoroughly established fact. Two centuries have elapsed since the theory of gravitation was enunciated, and although we do not understand its cause, we still must regard gravitation as a fundamental conception of natural philosophy, a conception which has enabled us to perceive much more than the metaphysicians did or could with their seeming omniscience. A hundred years later the conception of the elements arose; it made chemistry what it now is; and yet we have advanced as little in our comprehension of simple substances since the times of Lavoisier and Dalton as we have in our understanding of gravitation. The periodic law of the elements is only twenty years old; it is not surprising, therefore, that, knowing nothing about the causes of gravitation and mass, or about the nature of the elements, we do not comprehend the *rationale* of the periodic law. It is only by collecting established laws—that is, by working at the acquirement of truth—that we can hope gradually to lift the veil which conceals from us the causes of the mysteries of Nature and to discover their mutual dependency. Like the telescope and the microscope, laws founded on the basis of experiments are the instruments and means of enlarging our mental horizon.

In the remaining part of my communication I shall endeavour to show, and as briefly as possible, in how far the periodic law contributes to enlarge our range of vision. Before the promulgation of this law the chemical elements were mere fragmentary, incidental facts in Nature; there was no special reason to expect the discovery of new elements, and the new ones which were discovered from time to time appeared to be possessed of quite novel properties. The law of periodicity first enabled us to perceive undiscovered elements at a distance which formerly was inaccessible to chemical vision; and long ere they were discovered new elements appeared before our eyes possessed of a number of well-defined properties. We now know three cases of elements whose existence and properties were foreseen by the instrumentality of the periodic law. I need but mention the brilliant discovery of *gallium*, which proved to correspond to eka-aluminum of the periodic

law, by Lecoq de Boisbaudran, of *scandium,* corresponding to *ekaboron,* by Nilson; and of *germanium,* which proved to correspond in all respects to *ekasilicon,* by Winkler. When, in 1871, I described to the Russian Chemical Society the properties, clearly defined by the periodic law, which such elements ought to possess, I never hoped that I should be able to mention their discovery to the Chemical Society of Great Britain as a confirmation of the exactitude and the generality of the periodic law. Now that I have had the happiness of doing so, I unhesitatingly say that, although greatly enlarging our vision, even now the periodic law needs further improvements in order that it may become a trustworthy instrument in further discoveries.

SIR NORMAN LOCKYER

Sir Joseph Norman Lockyer was born at Rugby, England, May 17, 1836. He entered the War Office in 1857. His great scientific education is largely self-acquired. He is one of the originators of the meteoric hypothesis that the earth and other spheres are the result of the aggregation of meteorites. In chemistry he is working out the train of thought suggested by the periodic law that the atoms which we know are themselves compounds.

THE CHEMISTRY OF THE STARS

When, on returning from India, I found that you had during my absence done me the honor of unanimously electing me your president, I began to cast about for a subject on which to address you. Curiously enough, shortly afterwards an official inquiry compelled me to make myself acquainted with the early doings of the Royal Commission of the Exhibition of 1851, on which I have lately been elected to serve, and in my reading I found a full account of the establishment of your institute; of the laying of the foundation stone by the late Prince Consort in 1855, and of his memorable speech on that occasion. Here, I thought, was my subject; and when I heard that the admirable work

done by this and other local institutions had determined the inhabitants of this important city and neighborhood to crown the edifice by the foundation of a university, I thought the matter settled.

This idea, however, was nipped in the bud by a letter which informed me that the hope had been expressed that I should refer to some branch of astronomical work. I yielded at once, and because I felt that I might thus be able to show cause why the making of knowledge should occupy a large place in your new university, and thus distinguish it from other universities more or less decadent.

The importance of practical work, the educational value of the seeking after truth by experiment and observation on the part of even young students, are now generally recognized. That battle has been fought and won. But there is a tendency in the official direction of seats of learning to consider what is known to be useful, because it is used, in the first place. The fact that the unknown, that is, the unstudied, is the mine from which all scientific knowledge with its million applications has been won is too often forgotten.

Bacon, who was the first to point out the importance of experiment in the physical sciences, and who predicted the applications to which I have referred, warns us that "*lucifera experimenta non fructifera quaerenda;*" and surely we should highly prize those results which enlarge the domain of human thought and help us to understand the mechanism of the wonderful universe in which our lot is cast, as well as those which add to the comfort and the convenience of our lives.

It would be also easy to show by many instances how researches, considered ideally useless at the time they were made, have been the origin of the most tremendous applications. One instance suffices. Faraday's trifling with wires and magnets has already landed us in one of the greatest revolutions which civilization has witnessed; and where the triumphs of electrical science will stop no man can say.

This is a case in which the useless has been rapidly sublimed into utility so far as our material wants are concerned.

I propose to bring to your notice another "useless" observation suggesting a line of inquiry which I believe sooner or later is destined profoundly to influence human thought along many lines.

Fraunhofer at the beginning of this century examined sunlight and starlight through a prism. He found that the light received from the sun differed from that of the stars. So uselss did his work appear that we had to wait for half a century till any considerable advance was

made. It was found at last that the strange "lines" seen and named by Fraunhofer were precious indications of the chemical substances present in worlds immeasurably remote. We had, after half a century's neglect, the foundation of solar and stellar chemistry, an advance in knowledge equaling any other in its importance.

In dealing with my subject I shall first refer to the work which has been done in more recent years with regard to this chemical conditioning of the atmospheres of stars, and afterwards very briefly show how this work carries us into still other new and wider fields of thought.

The first important matter which lies on the surface of such a general inquiry as this is that if we deal with the chemical elements as judged by the lines in their spectra we know for certain of the existence of oxygen, of nitrogen, of argon, representing one class of gases, in no celestial body whatever; whereas, representing other gases, we have a tremendous demonstration of the existence of all the known lines of hydrogen and helium.

We see, then, that the celestial sorting out of gases is quite different from the terrestrial one.

Taking the substances classed by the chemist as non-metals, we find carbon and silicium—I prefer, on account of its stellar behavior, to call it silicium, though it is old fashioned—present in celestial phenomena. We have evidence of this in the fact that we have a considerable development of carbon in some stars and an indication of silicium in others. But these are the only non-metals observed. Now, with regard to the metallic substances which we find, we deal chiefly with calcium, strontium, iron, and magnesium. Others are not absolutely absent, but their percentage quantity is so small that they are negligible in a general statement.

Now do these chemical elements exist indiscriminately in all the celestial bodies, so that practically, from a chemical point of view, the bodies appear to us of similar chemical constitution? No; it is not so.

From the spectra of those stars which resemble the sun, in that they consist of an interior nucleus surrounded by an atmosphere which absorbs the light of the nucleus, and which, therefore, we study by means of this absorption, it is to be gathered that the atmospheres of some stars are chiefly gaseous—i. e., consisting of elements we recognize as gases here—of others chiefly metallic, of others again mainly composed of carbon or compounds of carbon.

Here, then, we have spectroscopically revealed the fact that there is

considerable variation in the chemical constituents which build up the stellar atmospheres.

This, though a general, is still an isolated statement. Can we connect it with another? One of the laws formulated by Kirchhoff in the infancy of spectroscopic inquiry has to do with the kind of radiation given out by bodies at different temperatures. A poker placed in a fire first becomes red, and, as it gets hotter, white hot. Examined in a spectroscope, we find that the red condition comes from the absence of blue light; that the white condition comes from the gradual addition of blue as the temperature increases.

The law affirms that the hotter a mass of matter is the farther its spectrum extends into the ultraviolet.

Hence the hotter a star is the farther does its complete or continuous spectrum lengthen out toward the ultraviolet and the less it is absorbed by cooler vapors in its atmosphere.

Now, to deal with three of the main groups of stars, we find the following very general result:

Gaseous stars.................................	Longest spectrum.
Metallic stars................................	Medium spectrum.
Carbon stars..................................	Shortest spectrum

We have now associated two different series of phenomena, and we are enabled to make the following statement:

Gaseous stars..............................	Highest temperature.
Metallic stars..............................	Medium temperature.
Carbon stars...............................	Lowest temperature.

Hence the differences in apparent chemical constitutions are associated with differences of temperature.

Can we associate with the two to which I have already called attention still a third class of facts? Laboratory work enables us to do this. When I began my inquiries the idea was, one gas or vapor, one spectrum. We now know that this is not true; the systems of bright lines given out by radiating substances change with the temperature.

We can get the spectrum of a well known compound substance—say carbonic oxide; it is one special to the compound; we increase the temperature so as to break up the compound, and we then get the spectra of its constituents, carbon and oxygen.

But the important thing in the present connection is that the spectra of the chemical elements behave exactly in the same way as the spectra of known compounds do when we employ temperatures far higher than those which break up the compounds; and indeed in some

cases the changes are more marked. For brevity I will take for purposes of illustration three substances, and deal with one increase of temperature only, a considerable one and obtainable by rendering a substance incandescent, first by a direct current of electricity, as happens in the so-called "arc lamps" employed in electric lighting, and next by the employment of a powerful induction coil and battery of Leyden jars. In laboratory parlance we pass thus from the arc to the jar-spark. In the case of magnesium, iron, and calcium, the changes observed on passing from the temperature of the arc to that of the spark have been minutely observed. In each, new lines are added or old ones are intensified at the higher temperature. Such lines have been termed "enhanced lines."

These enhanced lines are not seen alone; outside the region of high temperature in which they are produced, the cooling vapors give us the cool lines. Still we can conceive the enhanced lines to be seen alone at the highest temperature in a space sufficiently shielded from the action of all lower temperatures, but such a shielding is beyond our laboratory expedients.

In watching the appearance of these special enhanced lines in stellar spectra we have a third series of phenomena available, and we find that the results are absolutely in harmony with what has gone before. Thus:

Gaseous stars..	**Highest temperature..**	**Strong helium and faint enhanced lines.**
Metallic stars..	**Medium temperature..**	**Feeble helium and strong enhanced lines.** **No helium and strong arc lines.**
Carbon stars...	**Lowest temperature..**	**Faint arc lines.**

It is clear now, not only that the spectral changes in stars are associated with, or produced by, changes of temperature, but that the study of the enhanced spark and the arc lines lands us in the possibility of a rigorous stellar thermometry, such lines being more easy to observe than the relative lengths of spectrum.

Accepting this, we can take a long stride forward and, by carefully studying the chemical revelations of the spectrum, classify the stars along a line of temperature. But which line? Were all the stars in popular phraseology created hot? If so, we should simply deal with the running down of temperature, and because all the hottest stars are chemically alike, all cooler stars would be alike. But there are two very distinct groups of coolest stars; and since there are two different kinds of coolest stars, and only one kind of hottest stars, it cannot be merely a question either of a running up or a running down of temperature.

Many years of very detailed inquiry have convinced me that all stars save the hottest must be sorted out into two series—those getting hotter and those, like our sun, getting cooler, and that the hottest stage in the history of a star is reached near the middle of its life.

The method of inquiry adopted has been to compare large-scale photographs of the spectra of the different stars taken by my assistants at South Kensington; the complete harmony of the results obtained along various lines of other work carries conviction with it.

We find ourselves here in the presence of minute details exhibiting the workings of a chemical law, associated distinctly with temperature; and more than this, we are also in the presence of high temperature furnaces, entirely shielded by their vastness from the presence of those distracting phenomena which we are never free from in the most perfect conditions of experiment we can get here.

What, then, is the chemical law? It is this: In the very hottest stars we deal with the gases hydrogen, helium, and doubtless others still unknown, almost exclusively. At the next lowest temperatures we find these gases being replaced by metals in the state in which they are observed in our laboratories when the most powerful jar-spark is employed. At a lower temperature still the gases almost disappear entirely, and the metals exist in the state produced by the electric arc. Certain typical stars showing these chemical changes may be arranged as follows:

Stars getting hotter. — **Hottest stars.** — **Stars cooling.**

Bellatrix
ζ Tauri — **β Persei**
Rigel — **γ Lyræ**
α Cygni — **Castor**
γ Cygni — **Procyon**
α Orionis — **Arcturus and Sun.**

This, then, is the result of our first inquiry into the existence of the various chemical elements in the atmospheres of stars generally. We get a great diversity, and we know that this diversity accompanies changes of temperature. We have also found that the sun, which we independently know to be a cooling star, and Arcturus are identical chemically.

We have now dealt with the presence of the various chemical elements generally in the atmospheres of stars. The next point we have to consider is, whether the absorption which the spectrum indicates for us takes place from top to bottom of the atmosphere or only in certain levels.

In many of these stars the atmosphere may be millions of miles high. In each the chemical substances in the hottest and coldest portions may be vastly different. The region, therefore, in which this absorption takes place, which spectroscopically enables us to discriminate star from star, must be accurately known before we can obtain the greatest amount of information from our inquiries.

Our next duty then, clearly, is to study the sun—a star so near us that we can examine the different parts of its atmosphere, which we cannot do in the case of the more distant stars. By doing this we may secure facts which will enable us to ascertain in what parts of the atmosphere the absorption takes place which produces the various phenomena on which the chemical classification has been based.

It is obvious that the general spectrum of the sun, like that of stars generally, is built up of all the absorptions which can make themselves felt in every layer of its atmosphere from bottom to top; that is, from the photosphere to the outermost part of the corona. Let me remind you that this spectrum is changeless from year to year.

Now, sun-spots are disturbances produced in the photosphere; and the chromosphere, with its disturbances, called prominences, lies directly above it. Here, then, we are dealing with the lowest part of the sun's atmosphere. We find first of all that, in opposition to the changeless general spectrum, great changes occur with the sun-spot period, both in the spots and chromosphere.

The spot spectrum is indicated, as was found in 1866, by the widening of certain lines; the chromospheric spectrum, as was found in 1868, by the appearance at the sun's limb of certain bright lines. In both cases the lines affected, seen at any one time, are relatively few in number.

In the spot spectrum, at a sun-spot minimum, we find iron lines chiefly affected; at a maximum they are chiefly of unknown or unfamiliar origin. At the present moment the affected lines are those recorded in the spectra of vanadium and scandium, with others never seen in a laboratory. That we are here far away from terrestrial chemical conditions is evidenced by the fact that there is not a gram of scandium available for laboratory use in the world at the present time.

Then we have the spectrum of the prominences and the chromosphere. That spectrum we are enabled to observe every day when the sun shines as conveniently as we can observe that of sun spots. The chromosphere is full of marvels. At first, when our knowledge of spectra was very much more restricted than now, almost all the lines

observed were unknown. In 1868 I saw a line in the yellow, which I found behaved very much like hydrogen, though I could prove that it was not due to hydrogen; for laboratory use the substance which gave rise to it I called helium. Next year I saw a line in the green at 1474 of Kirchhoff's scale. That was an unknown line, but in some subsequent researches I traced it to iron. From that day to this we have observed a large number of lines. They have gradually been dragged out from the region of the unknown, and many are now recognized as enhanced lines, to which I have already called attention as appearing in the spectra of metals at a very high temperature.

But useful as the method of observing the chromosphere without an eclipse, which enables us

"... to feel from world to world,"

as Tennyson has put it, has proved, we want an eclipse to see it face to face.

A tremendous flood of light has been thrown upon it by the use of large instruments constructed on a plan devised by Respighi and myself in 1871. These give us an image of the chromosphere painted in each one of its radiations, so that the exact locus of each chemical layer is revealed. One of the instruments employed during the Indian eclipse of this year is that used in photographing the spectra of stars, so that it is now easy to place photographs of the spectra of the chromosphere obtained during a total eclipse and of the various stars side by side.

I have already pointed out that the chemical classification indicated that the stars next above the sun in temperature are represented by γ Cygni and Procyon, one on the ascending, the other on the descending branch of the temperature curve.

Studying the spectra photographed during the eclipse of this year we see that practically the lower part of the sun's atmosphere, if present by itself, would give us the lines which specialize the spectra of γ Cygni or Procyon.

I recognize in this result a veritable Rosetta stone, which will enable us to read the celestial hieroglyphics presented to us in stellar spectra, and help us to study the spectra and to get at results much more distinctly and certainly than ever before.

One of the most important conclusions we draw from the Indian eclipse is that, for some reason or other, the lowest, hottest part of the sun's atmosphere does not write its record among the lines which build up the general spectrum so effectively as does a higher one.

There was another point especially important on which we hoped for information, and that was this: Up to the employment of the prismatic camera insufficient attention had been directed to the fact that in observations made by an ordinary spectroscope no true measure of the height to which the vapors or gases extended above the sun could be obtained; early observations, in fact, showed the existence of glare between the observer and the dark moon; hence it must exist between us and the sun's surroundings.

The prismatic camera gets rid of the effects of this glare, and its results indicate that the effective absorbing layer—that, namely, which gives rise to the Fraunhofer lines—is much more restricted in thickness than was to be gathered from the early observations.

We are justified in extending these general conclusions to all the stars that shine in the heavens.

So much, then, in brief, for solar teachings in relation to the record of the absorption of the lower parts of stellar atmospheres.

Let us next turn to the higher portions of the solar surroundings, to see if we can get any effective help from them.

In this matter we are dependent absolutely upon eclipses, and I shall fulfill my task very badly if I do not show you that the phenomena then observable when the so-called corona is visible, full of awe and grandeur to all, are also full of precious teaching to the student of science. This also varies like the spots and prominences with the sun-spot period.

It happened that I was the only person that saw both the eclipse of 1871 at the maximum of the sun-spot period and that of 1878 at minimum; the corona of 1871 was as distinct from the corona of 1878 as anything could be. In 1871 we got nothing but bright lines, indicating the presence of gases; namely, hydrogen and another, since provisionally called coronium. In 1878 we got no bright lines at all, so I stated that probably the changes in the chemistry and appearance of the corona would be found to be dependent upon the sun-spot period, and recent work has borne out that suggestion.

I have now specially to refer to the corona as observed and photographed this year in India by means of the prismatic camera, remarking that an important point in the use of the prismatic camera is that it enables us to separate the spectrum of the corona from that of the prominences.

One of the chief results obtained is the determination of the position

of several lines of probably more than one new gas, which, so far, have not been recognized as existing on the earth.

Like the lowest hottest layer, for some reason or other, this upper layer does not write its record among the lines which build up the general spectrum.

GENERAL RESULTS REGARDING THE LOCUS OF ABSORPTION IN STELLAR ATMOSPHERES

We learn from the sun, then, that the absorption which defines the spectrum of a star is the absorption of a middle region, one shielded both from the highest temperature of the lowest reaches of the atmosphere, where most tremendous changes are continually going on and the external region where the temperature must be low, and where the metallic vapors must condense.

If this is true for the sun it must be equally true for Arcturus, which exactly resembles it. I go further than this, and say that in the presence of such definite results as those I have brought before you it is not philosophical to assume that the absorption may take place at the bottom of the atmosphere of one star or at the top of the atmosphere of another. The *onus probandi* rests upon those who hold such views.

So far I have only dealt in detail with the hotter stars, but I have pointed out that we have two distinct kinds of coolest ones, the evidence of their much lower temperature being the shortness of their spectra. In one of these groups we deal with absorption alone, as in those already considered; we find an important break in the phenomena observed; helium, hydrogen, and metals have practically disappeared, and we deal with carbon absorption alone.

But the other group of coolest stars presents us with quite new phenomena. We no longer deal with absorption alone, but accompanying it we have radiation, so that the spectra contain both dark lines and bright ones. Now, since such spectra are visible in the case of new stars, the ephemera of the skies, which may be said to exist only for an instant relatively, and when the disturbance which gives rise to their sudden appearance has ceased, we find their places occupied by nebulæ, we cannot be dealing here with stars like the sun, which has already taken some millions of years to slowly cool, and requires more millions to complete the process into invisibility.

The bright lines seen in the large number of permanent stars which resemble these fleeting ones—new stars, as they are called—are those discerned in the once mysterious nebulæ which, so far from being stars,

were supposed not many years ago to represent a special order of created things.

Now the nebulæ differ from stars generally in the fact that in their spectra we have practically to deal with radiation alone; we study them by their bright lines; the conditions which produce the absorption by which we study the chemistry of the hottest stars are absent.

A NEW VIEW OF STARS

Here, then, we are driven to the perfectly new idea that some of the cooler bodies in the heavens, the temperature of which is increasing and which appear to us as stars, are really disturbed nebulæ.

What, then, is the chemistry of the nebulæ? It is mainly gaseous; the lines of helium and hydrogen and the flutings of carbon, already studied by their absorption in the groups of stars to which I have already referred, are present as bright ones.

The presence of the lines of the metals iron, calcium, and probably magnesium, shows us that we are not dealing with gases merely.

Of the enhanced metallic lines there are none; only the low temperature lines are present, so far as we yet know. The temperature, then, is low, and lowest of all in those nebulæ where carbon flutings are seen almost alone.

A NEW VIEW OF NEBULAE

Passing over the old views, among them one that the nebulæ were holes in something dark which enabled us to see something bright beyond, and another that they were composed of a fiery fluid, I may say that not long ago they were supposed to be masses of gases only, existing at a very high temperature.

Now, since gases may glow at a low temperature as well as at a high one, the temperature evidence must depend upon the presence of cool metallic lines and the absence of the enhanced ones.

The nebulæ, then, are relatively cool collections of some of the permanent gases and of some cool metallic vapors, and both gases and metals are precisely those I have referred to as writing their records most visibly in stellar atmospheres.

Now, can we get more information concerning this association of certain gases and metals? In laboratory work it is abundantly recognized that all meteorites (and many minerals) when slightly heated give out permanent gases, and under certain conditions the spectrum

of the nebulæ may in this way be closely approximated to. I have not time to labor this point, but I may say that a discussion of all the available observations to my mind demonstrates the truth of the suggestion, made many years ago by Professor Tait before any spectroscopic facts were available, that the nebulæ are masses of meteorites rendered hot by collisions.

Surely human knowledge is all the richer for this indication of the connection between the nebulæ, hitherto the most mysterious bodies in the skies, and the "stones that fall from heaven."

CELESTIAL EVOLUTION

But this is, after all, only a stepping stone, important though it be. It leads us to a vast generalization. If the nebulæ are thus composed, they are bound to condense to centers, however vast their initial proportions, however irregular the first distribution of the cosmic clouds which compose them. Each pair of meteorites in collision puts us in mental possession of what the final stage must be. We begin with a feeble absorption of metallic vapors round each meteorite in collision; the space between the meteorites is filled with the permanent gases driven out farther afield and having no power to condense. Hence dark metallic and bright gas lines. As time goes on the former must predominate, for the whole swarm of meteorites will then form a gaseous sphere with a strongly heated center, the light of which will be absorbed by the exterior vapor.

The temperature order of the group of stars with bright lines as well as dark ones in their spectra has been traced, and typical stars indicating the chemical changes have been as carefully studied as those in which absorption phenomena are visible alone, so that now there are no breaks in the line connecting the nebulæ with the stars on the verge of extinction.

Here we are brought to another tremendous outcome—that of the evolution of all cosmical bodies from meteorites, the various stages recorded by the spectra being brought about by the various conditions which follow from the conditions.

These are, shortly, that at first collisions produce luminosity among the colliding particles of the swarm, and the permanent gases are given off and fill the interspaces. As condensation goes on, the temperature at the center of condensation always increasing, all the meteorites in time are driven into a state of gas. The meteoritic bombardment prac-

tically now ceases for lack of material, and the future history of the mass of gas is that of a cooling body, the violent motions in the atmosphere while condensation was going on now being replaced by a relative calm.

The absorption phenomena in stellar spectra are not identical at the same mean temperature on the ascending and descending sides of the curve, on account of the tremendous difference in the physical conditions.

In a condensing swarm, the center of which is undergoing meteoritic bombardment from all sides, there cannot be the equivalent of the solar chromosphere; the whole mass is made up of heterogeneous vapor at different temperatures and moving with different velocities in different regions.

In a condensed swarm, of which we can take the sun as a type, all action produced from without has practically ceased; we get relatively a quiet atmosphere and an orderly assortment of the vapors from top to bottom, disturbed only by the fall of condensed metallic vapors. But still, on the view that the differences in the spectra of the heavenly bodies chiefly represent differences in degree of condensation and temperature, there can be *au fond*, no great chemical difference between bodies of increasing and bodies of decreasing temperature. Hence we find at equal mean temperatures on opposite sides of the temperature curve this chemical similarity of the absorbing vapors proved by many points of resemblance in the spectra, especially the identical behavior of the enhanced metallic and cleveite lines.

CELESTIAL DISSOCIATION

The time you were good enough to put at my disposal is now exhausted, but I cannot conclude without stating that I have not yet exhausted all the conceptions of a high order to which Fraunhofer's apparently useless observation has led us.

The work which to my mind has demonstrated the evolution of the cosmos as we know it from swarms of meteorites, has also suggested a chemical evolution equally majestic in its simplicity.

A quarter of a century ago I pointed out that all the facts then available suggested the hypothesis that in the atmospheres of the sun and stars various degrees of "celestial dissociation" were at work, a "dissociation" which prevented the coming together of the finest particles of matter which at the temperature of the earth and at all arti-

ficial temperature yet attained here compose the metals, the metalloids and compounds.

On this hypothesis the so-called atoms of the chemist represent not the origins of things, but only early stages of the evolutionary process.

At the present time we have tens of thousands of facts which were not available twenty-five years ago. All these go to the support of the hypothesis, and among them I must indicate the results obtained at the last eclipse, dealing with the atmosphere of the sun in relation to that of the various stars of higher temperature to which I called your attention. In this way we can easily explain the enhanced lines of iron existing practically alone in Alpha Cygni. I have yet to learn any other explanation.

I have nothing to take back, either from what I then said or what I have said since on this subject, and although the view is not yet accepted, I am glad to know that many other lines of work which are now being prosecuted tend to favor it.

I have no hesitation in expressing my conviction that in a not distant future the inorganic evolution to which we have been finally led by following up Fraunhofer's useless experiment will take its natural place side by side with that organic evolution, the demonstration of which has been one of the glories of the nineteenth century.

And finally now comes the moral of my address. If I have helped to show that observations having no immediate practical bearing may yet help on the thought of mankind, and that this is a thing worth the doing, let me express a hope that such work shall find no small place in the future University of Birmingham.

BIOLOGY

IN 1876 WEISMANN brought forward his theory of heredity. This was a step in the doctrine of evolution. It denied the transmission of acquired characters, and did much to explain the process of heredity by the division of the parent cell. Whether or not we accept his thesis that acquired characters are never inherited, great credit is due him for his explanation of heredity. The principles of his theory are given below.

The most important step in biology in the last of the century is the development of the science of bacteriology. In 1849-50 Pollender and Devaine discovered minute bodies in animals that had died of anthrax. They called them bacteria, but did not yet consider them the cause of the disease. At this time the doctrine of spontaneous generation held full sway. Nobody dreamed of asking why wounds gangrened, grapes moulded, wine soured, or like seemingly foolish questions. But about 1857 Pasteur took up the study of fermentation and showed conclusively that its cause is the presence and growth of a micro-organism. Devaine in 1863 re-investigated anthrax from this point of view and showed that such microbes were regularly present in the blood of animals that had died of the disease. In 1865 Pasteur showed that the way to prevent the silkworm disease, then ruining the industry in France, was to destroy everything infected with the microbe which caused the disease. In 1870 Koch of Wollstein took up the subject and invented his method of pure cultivation of the bacteria by cultivating them in a thin layer of jelly between glass plates, picking out species, and thus recultivating and selecting until the product was absolutely of one kind.

Pasteur and Cohn, by a series of the most careful experiments, conducted independently, gave the final blow to the spontaneous generation theory in the early seventies.

Pasteur began applying his method of inoculation about 1876. The first successful experiment was on animals inoculated with anthrax. The uninoculated died; the protected suffered no harm. Inoculation for chicken cholera was also successful. The germ has been found of tuberculosis (Koch, 1882), typhoid fever (Eberth, 1880), diphtheria (Klebs-Loeffler, 1883), cholera (Koch, 1884), lockjaw (Nicholaier, 1884), the grip (Canon, 1892), pneumonia (Frankel, 1886), etc. Pasteur's treatment for hydrophobia, and Behring's antitoxin give great hopes for the ultimate success of inoculation.

AUGUST WEISMANN

Dr. August Weismann was born Jan. 17, 1834 at Frankfort-on-the-Main, where his father was Professor of Philology in the Lyceum. He studied medicine at Göttingen from 1852 to 1856. He was physician to the Archduke of Austria from 1860 to 1862. For the next ten years he could do no microscopic work on account of his eyesight. He studied Darwin's theory of evolution closely and formed a great admiration for him. In 1876 he published *Studies in the Theory of Descent.* This book commanded a great deal of attention among scientists and in the preface to the English translation of the work Darwin wrote: "At the present time there is hardly any question in biology of more importance than the nature and cause of variability (in individuals)." Since the death of Darwin, Dr. Weismann has developed his theory of descent on purely original lines. It may be said that he conceives the germ-plasm as the basis of heredity. Dr. Weismann denies the transmission to a descendant of any quality, including contagious disease, acquired after birth. He regards sexual reproduction as a stupendous organization, by which nature is ever mixing together and forming new combinations of the hereditary qualities of a whole species. His principles are now accepted by the foremost scientists of Germany, where he has occupied the chair of zoology in Freidburg University since 1862, but in England the heated controversy which arose on the promulgation of his germ-plasm theory is still active.

THE CONTINUITY OF THE GERM-PLASM AS THE FOUNDATION OF A THEORY OF HEREDITY

Introduction

When we see that, in the higher organisms, the smallest structural details, and the most minute peculiarities of bodily and mental disposition, are transmitted from one generation to another; when we find in all species of plants and animals a thousand characteristic peculiarities of structure continued unchanged through long series of generations; when we even see them in many cases unchanged throughout whole geological periods; we very naturally ask for the causes of such a strikthe phenomenon: and inquire how it is that such facts become possible, how it is that the individual is able to transmit its structural features to its offspring with such precision. And the immediate answer to such a question must be given in the following terms:—"A single cell out of the millions of diversely differentiated cells which compose the body, becomes specialized as a sexual cell; it is thrown off from the organism and is capable of reproducing all the peculiarities of the parent body, in the new individual which springs from it by cell-division and the complex process of differentiation." Then the more precise question follows: "How is it that such a single cell can reproduce the *tout ensemble* of the parent with all the faithfulness of a portrait?"

The answer is extremely difficult; and no one of the many attempts to solve the problem can be looked upon as satisfactory; no one of them can be regarded as even the beginning of a solution or as a secure foundation from which a complete solution may be expected in the future. Neither Häckel's "Perigenesis of the Plastidule," nor Darwin's "Pangenesis," can be regarded as such a beginning. The former hypothesis does not really treat of that part of the problem which is here placed in the foreground, viz., the explanation of the fact that the tendencies of heredity are present in single cells, but it is rather concerned with the question as to the manner in which it is possible to conceive the transmission of a certain tendency of development into the sexual cell, and ultimately into the organism arising from it. The same may be said of the hypothesis of His, who, like Häckel regards heredity as the transmission of certain kinds of motion. On the other hand, it must be conceded that Darwin's hypothesis goes to the very root of the question,

but he is content to give, as it were, a provisional or purely formal solution, which, as he himself says, does not claim to afford insight into the real phenomena, but only to give us the opportunity of looking at all the facts of heredity from a common standpoint. It has achieved this end, and I believe it has unconsciously done more, in that the thoroughly logical application of its principles has shown that the real causes of heredity cannot lie in the formation of gemmules or in any allied phenomena. The improbabilities to which any such theory would lead are so great that we can affirm with certainty that its details cannot accord with existing facts. Furthermore, Brooks' well-considered and brilliant attempt to modify the theory of Pangenesis cannot escape the reproach that it is based upon possibilities, which one might certainly describe as improbabilities. But although I am of the opinion that the whole foundation of the theory of Pangenesis, however it may be modified, must be abandoned, I think, nevertheless, its author deserves great credit, and that its production has been one of those indirect roads along which science has been compelled to travel in order to arrive at the truth. Pangenesis is a modern revival of the oldest theory of heredity, that of Democritus, according to which the sperm is secreted from all parts of the body of both sexes during copulation, and is animated by a bodily force; according to this theory also, the sperm from each part of the body reproduces the same part.

If, according to the received physiological and morphological ideas of the day, it is impossible to imagine that gemmules produced by each cell of the organism are at all times to be found in all parts of the body, and furthermore that these gemmules are collected in the sexual cells, which are then able to again reproduce in a certain order each separate cell of the organism, so that each sexual cell is capable of developing into the likeness of the parent body; if all this is inconceivable, we must inquire for some other way in which we can arrive at a foundation for the true understanding of heredity. My present task is not to deal with the whole question of heredity, but only with the single although fundamental question—"How is it that a single cell of the body can contain within itself all the hereditary tendencies of the whole organism?" I am here leaving out of account the further question as to the forces and the mechanism by which these tendencies are developed in the building-up of the organism. On this account I abstain from considering at present the views of Nägeli, for as will be shown later on, they only slightly touch this fundamental question, although they may certainly

claim to be of the highest importance with respect to the further question alluded to above.

Now if it is impossible for the germ-cell to be, as it were, an extract of the whole body, and for all the cells of the organism to dispatch small particles to the germ-cells, from which the latter derive their power of heredity; then there remain, as it seems to me, only two other possible, physiologically conceivable, theories as to the origin of germ-cells, manifesting such powers as we know they possess. Either the substance of the parent germ-cell is capable of undergoing a series of changes which, after the building-up of a new individual leads back again to identical germ-cells; or the germ-cells are not derived at all, as far as their essential and characteristic substance is concerned, from the body of the individual, but they are derived directly from the parent germ-cell.

I believe that the latter view is the true one: I have expounded it for a number of years, and have attempted to defend it, and to work out its further details in various publications. I propose to call it the theory of "The Continuity of the Germ-plasm," for it is founded upon the idea that heredity is brought about by the transference from one generation to another of a substance with a definite chemical, and above all, molecular constitution. I have called this substance "germ-plasm," and have assumed that it possesses a highly complex structure, conferring upon it the power of developing into a complex organism. I have attempted to explain heredity by supposing that in each ontogeny a part of the specific germ-plasm contained in the parent egg-cell is not used up in the construction of the body of the offspring, but is reserved unchanged for the formation of the germ-cells of the following generation.

It is clear that this view of the origin of germ-cells explains the phenomena of heredity very simply, inasmuch as heredity becomes thus a question of growth and of assimilation,—the most fundamental of all vital phenomena. If the germ-cells of successive generations are directly continuous, and thus only form, as it were, different parts of the same substance, it follows that these cells must, or at any rate may, possess the same molecular constitution, and that they would therefore pass through exactly the same stages under certain conditions of development, and would form the same final product. The hypothesis of the continuity of the germ-plasm gives an identical starting point to each successive generation, and thus explains how it is that an identical product arises from all of them. In other words, the hypothesis explains heredity as part of the underlying problems of assimilation and of the

causes which act directly during ontogeny; it therefore builds a foundation from which the explanation of these phenomena can be attempted.

It is true that this theory also meets with difficulties, for it seems to be unable to do justice to a certain class of phenomena, viz., the transmission of so-called acquired characters. I therefore gave immediate and special attention to this point in my first publication on heredity, and I believe that I have shown that the hypothesis of the transmission of acquired characters—up to that time generally accepted—is, to say the least, very far from being proved, and that entire classes of facts which have been interpreted under this hypothesis may be quite as well interpreted otherwise, while in many cases they must be explained differently. I have shown that there is no ascertained fact which, at least up to the present time, remains in irrevocable conflict with the hypothesis of the continuity of the germ-plasm; and I do not know any reason why I should modify this opinion to-day, for I have not heard of any objection which appears to be feasible. E. Roth has objected that in pathology we everywhere meet with the fact that acquired local disease may be transmitted to the offspring as a predisposition; but all such cases are exposed to the serious criticism that the very point that first needs to be placed on a secure footing is incapable of proof, viz., the hypothesis that the causes which in each particular case led to the predisposition were really acquired. It is not my intention, on the present occasion, to enter fully into the question of acquired characters; I hope to be able to consider the subject in greater detail at a future date. But in the meantime I should wish to point out that we ought, above all, to be clear as to what we really mean by the expression "acquired character." An organism cannot acquire anything unless it already possesses the predisposition to acquire it: acquired characters are therefore no more than local or sometimes general variations which arise under the stimulus provided by certain external influences. If by the long-continued handling of a rifle, the so-called "*Exercierknochen*" (a bony growth caused by the pressure of the weapon in drilling) is developed, such a result depends upon the fact that the bone in question, like every other bone, contains within itself a predisposition to react upon certain mechanical stimuli, by growth in a certain direction and to a certain extent. The predisposition towards an "*Exercierknochen*" is therefore already present, or else the growth could not be formed; and the same reasoning applies to all other "acquired characters."

Nothing can arise in an organism unless the predisposition to it is

pre-existent, for every acquired character is simply the reaction of the organism upon a certain stimulus. Hence I should never have thought of asserting that predispositions cannot be transmitted, as E. Roth appears to believe. For instance, I freely admit that the predisposition to an "*Exercierknochen*" varies, and that a strongly marked predisposition may be transmitted from father to son, in the form of bony tissue with a more susceptible constitution. But I should deny that the son could develop an "*Exercierknochen*" without having drilled, or that, after having drilled, he could develop it more easily than his father, on account of the drilling through which the latter first acquired it. I believe that this is as impossible as that the leaf of an oak should produce a gall without having been pierced by a gall-producing insect, as a result of the thousands of antecedent generations of oaks which have been pierced by such insects, and have thus "acquired" the power of producing galls. I am also far from asserting that the germ-plasm—which, as I hold, is transmitted as the basis of heredity from one generation to another—is absolutely unchangeable or totally uninfluenced by forces residing in the organism within which it is transformed into germ-cells. I am also compelled to admit that it is conceivable that organisms may exert a modifying influence upon their germ-cells, and even that such a process is to a certain extent inevitable. The nutrition and growth of the individual must exercise some influence upon its germ-cells; but in the first place this influence must be extremely slight, and in the second place it cannot act in the manner in which it is usually assumed that it takes place. A change of growth at the periphery of an organism, as in the case of an "*Exercierknochen*," can never cause such a change in the molecular structure of the germ-plasm as would augment the predisposition to an "*Exercierknochen*," so that the son would inherit an increased susceptibility of the bony tissue or even of the particular bone in question. But any change produced will result from the reaction of the germ-cell upon changes of nutrition caused by alteration in growth at the periphery, leading to some change in the size, number, or arrangement of its molecular units. In the present state of our knowledge there is reason for doubting whether such reaction can occur at all; but, if it can take place, at all events the quality of the change in the germ-plasm can have nothing to do with the quality of the acquired character, but only with the way in which the general nutrition is influenced by the latter. In the case of the "*Exercierknochen*" there would be practically no change in the general nutrition, but if such a bony

growth could reach the size of a carcinoma, it is conceivable that a disturbance of the general nutrition of the body might ensue. Certain experiments on plants—on which Nägeli showed that they can be submitted to strongly varied conditions of nutrition for several generations, without the production of any visible hereditary change—show that the influence of nutrition upon the germ-cells must be very slight, and that it may possibly leave the molecular structure of the germ-plasm altogether untouched. This conclusion is also supported by comparing the uncertainty of these results with the remarkable precision with which heredity acts in the case of those characters which are known to be transmitted. In fact, up to the present time, it has never been proved that any changes in general nutrition can modify the molecular structure of the germ-plasm, and far less has it been rendered by any means probable that the germ-cells can be affected by acquired changes which have no influence on general nutrition. If we consider that each so-called predisposition (that is, a power of reacting upon a certain stimulus in a certain way, possessed by any organism or by one of its parts) must be innate, and further that each acquired character is only the predisposed reaction of some part of an organism upon some external influence; then we must admit that only one of the causes which produce any acquired character can be transmitted, the one which was present before the character itself appeared, viz., the predisposition; and we must further admit that the latter arises from the germ, and that it is quite immaterial to the following generation whether such predisposition comes into operation or not. The continuity of the germ-plasm is amply sufficient to account for such a phenomenon, and I do not believe that any objection to my hypothesis, founded upon the actually observed phenomena of heredity, will be found to hold. If it be accepted, many facts will appear in a light different from that which has been cast upon them by the hypothesis which has been hitherto received,—a hypothesis which assumes that the organism produces germ-cells afresh, again and again, and that it produces them entirely from its own substance. Under the former theory the germ-cells are no longer looked upon as the product of the parent's body, at least as far as their essential part—the specific germ-plasm—is concerned: they are rather considered as something which is to be placed in contrast with the *tout ensemble* of the cells which make up the parent's body, and the germ-cells of succeeding generations stand in a similar relation to one another as a series of generations of unicellular organisms, arising by a continued process of cell-division. It

is true that in most cases the generations of germ-cells do not arise immediately from one another as complete cells, but only as minute particles of germ-plasm. This latter substance, however, forms the foundation of the germ-cells of the next generation, and stamps them with their specific character. Previous to the publication of my theory, C. Jäger, and later M. Nussbaum, have expressed ideas upon heredity which come very near to my own. Both of these writers started with the hypothesis that there must be a direct connection between the germ-cells of succeeding generations, and they tried to establish such a continuity by supposing that the germ-cells of the offspring are separated from the parent germ-cell before the beginning of embryonic development, or at least before any histological differentiation has taken place. In this form their suggestion cannot be maintained, for it is in conflict with numerous facts. A continuity of the germ-cells does not now take place, except in very rare instances; but this fact does not prevent us from adopting a theory of the continuity of the germ-plasm, in favour of which much weighty evidence can be brought forward. In the following pages I shall attempt to develop further the theory of which I have just given a short account, to defend it against any objections which have been brought forward, and to draw from it new conclusions which may perhaps enable us more thoroughly to appreciate facts which are known, but imperfectly understood. It seems to me that this theory of the continuity of the germ-plasm deserves at least to be examined in all its details, for it is the simplest theory upon the subject, and the one which is most obviously suggested by the facts of the case, and we shall not be justified in forsaking it for a more complex theory until proof that it can be no longer maintained is forthcoming. It does not presuppose anything except facts which can be observed at any moment, although they may not be understood,—such as assimilation, or the development of like organisms from like germs; while every other theory of heredity is founded on hypotheses which cannot be proved. It is nevertheless possible that continuity of the germ-plasm does not exist in the manner in which I imagine that it takes place, for no one can at present decide whether all the ascertained facts agree with and can be explained by it. Moreover, the ceaseless activity of research brings to light new facts every day, and I am far from maintaining that my theory may not be disproved by some of these. But even if it should have to be abandoned at a later period, it seems to me that, at the present time, it is a necessary stage in the advancement of our knowledge, and

one which must be brought forward and passed through, whether it prove right or wrong, in the future. In this spirit I offer the following considerations, and it is in this spirit that I should wish them to be received.

I. The Germ-plasm

I entirely agree with Strasburger when he says, "The specific qualities of organisms are based upon nuclei;" and I further agree with him in many of his ideas as to the relation between the nucleus and cell-body: "Molecular stimuli proceed from the nucleus into the surrounding cytoplasm; stimuli which, on the one hand, control the phenomena of assimilation in the cell, and, on the other hand, give to the growth of the cytoplasm, which depends upon nutrition, a certain character peculiar to the species." "The nutritive cytoplasm assimilates, while the nucleus controls the assimilation, and hence the substances assimilated possess a certain constitution and nourish in a certain manner the cyto-idioplasm and the nuclear idioplasm. In this way the cytoplasm takes part in the phenomena of construction, upon which the specific form of the organism depends. This constructive activity of the cyto-idioplasm depends upon the regulative influence of the nuclei." The nuclei therefore "determine the specific direction in which an organism develops."

The opinion—derived from the recent study of the phenomena of fertilization—that the nucleus impresses its specific character upon the cell, has received conclusive and important confirmation in the experiments upon the regeneration of Infusoria, conducted simultaneously by M. Nussbaum at Bonn, and by A. Gruber at Freiburg. Nussbaum's statement that an artificially separated portion of a *Paramaecium*, which does not contain any nuclear substance, immediately dies, must not be accepted as of general application, for Gruber has kept similar fragments of other Infusoria alive for several days. Moreover, Gruber had previously shown that individual Protozoa occur, which live in a normal manner, and are yet without a nucleus, although this structure is present in other individuals of the same species. But the meaning of the nucleus is made clear by the fact, published by Gruber, that such artificially separated fragments of Infusoria are incapable of regeneration, while on the other hand those fragments which contain nuclei always regenerate. It is therefore only under the influence of the nucleus that the cell substance re-develops into the full type of the species. In adopting the view that the nucleus is the factor which deter-

mines the specific nature of the cell, we stand on a firm foundation upon which we can build with security.

If therefore the first segmentation nucleus contains, in its molecular structure, the whole of the inherited tendencies of development, it must follow that during segmentation and subsequent cell-division, the nucleoplasm will enter upon definite and varied changes which must cause the differences appearing in the cells which are produced; for identical cell-bodies depend, *ceteris paribus,* upon identical nucleoplasm, and conversely different cells depend upon differences in the nucleoplasm. The fact that the embryo grows more strongly in one direction than in another, that its cell-layers are of different nature and are ultimately differentiated into various organs and tissues,—forces us to accept the conclusion that the nuclear substance has also been changed in nature, and that such changes take place during ontogenetic development in a regular and definite manner. This view is also held by Strasburger, and it must be the opinion of all who seek to derive the development of inherited tendencies from the molecular structure of the germ-plasm, instead of from preformed gemmules.

We are thus led to the important question as to the forces by which the determining substance or nucleoplasm is changed, and as to the manner in which it changes during the course of ontogeny, and on the answer to this question our further conclusions must depend. The simplest hypothesis would be to suppose that, at each division of the nucleus, its specific substance divides into two halves of unequal quality, so that the cell-bodies would also be transformed; for we have seen that the character of a cell is determined by that of its nucleus. Thus in any Metazoon the first two segmentation spheres would be transformed in such a manner that one only contained the hereditary tendencies of the endoderm and the other those of the ectoderm, and therefore, at a later stage, the cells of the endoderm would arise from the one and those of the ectoderm from the other; and this is actually known to occur. In the course of further division the nucleoplasm of the first ectoderm cell would again divide unequally, *e. g.,* into the nucleoplasm containing the hereditary tendencies of the nervous system, and into that containing the tendencies of the external skin. But even then, the end of the unequal division of nuclei would not have been nearly reached; for, in the formation of the nervous system, the nuclear substance which contains the hereditary tendencies of the sense-organs would, in the course of further cell-division, be separated from that

which contains the tendencies of the central organs, and the same process would continue in the formation of all single organs, and in the final development of the most minute histological elements. This process would take place in a definitely ordered course, exactly as it has taken place throughout a very long series of ancestors; and the determining and directing factor is simply and solely the nuclear substance, the nucleoplasm, which possesses such a molecular structure in the germ-cell that all such succeeding stages of its molecular structure in future nuclei must necessarily arise from it, as soon as the requisite external conditions are present. This is almost the same conception of ontogenetic development as that which has been held by embryologists who have not accepted the doctrine of evolution: for we have only to transfer the primary cause of development, from an unknown source within the organism, into the nuclear substance, in order to make the views identical.

I believe I have shown that theoretically hardly any objections can be raised against the view that the nuclear substance of somatic cells may contain unchanged germ-plasm, or that this germ-plasm may be transmitted along certain lines. It is true that we might imagine *a priori* that all somatic nuclei contain a small amount of unchanged germ-plasm. In Hydroids such an assumption cannot be made, because only certain cells in a certain succession possess the power of developing into germ-cells; but it might well be imagined that in some organisms it would be a great advantage if every part possessed the power of growing up into the whole organism and of producing sexual cells under appropriate circumstances. Such cases might exist if it were possible for all somatic nuclei to contain a minute fraction of unchanged germ-plasm. For this reason, Strasburger's other objection against my theory also fails to hold; viz., that certain plants can be propagated by pieces of rhizomes, roots, or even by means of leaves, and that plants produced in this manner may finally give rise to flowers, fruit and seeds, from which new plants arise. "It is easy to grow new plants from the leaves of begonia which have been cut off and merely laid upon moist sand, and yet in the normal course of ontogeny the molecules of germ-plasm would not have been compelled to pass through the leaf; and they ought therefore to be absent from its tissue. Since it is possible to raise from the leaf a plant which produces flower and fruit, it is perfectly certain that special cells containing the germ substance cannot exist in the

plant." But I think that this fact only proves that in begonia and similar plants all the cells of the leaves or perhaps only certain cells contain a small amount of germ-plasm, and that consequently these plants are specially adapted for propagation by leaves. How is it then that all plants cannot be reproduced in this way? No one has ever grown a tree from the leaf of the lime or oak, or a flowering plant from the leaf of the tulip or convolvulus. It is insufficient to reply that in the last mentioned cases the leaves are more strongly specialized, and have thus become unable to produce germ-substance; for the leaf-cells in these different plants have hardly undergone histological differentiation in different degrees. If, notwithstanding, the one can produce a flowering plant, while the others have not this power, it is of course clear that reasons other than the degree of histological differentiation must exist; and, according to my opinion, such a reason is to be found in the admixture of a minute quantity of unchanged germ-plasm with some of their nuclei.

In Sach's excellent lectures on the physiology of plants, we read on page 723—"In the true mosses almost any cell of the roots, leaves and shoot-axes, and even of the immature sporogonium, may grow out under favourable conditions, become rooted, form new shoots, and give rise to an independent living plant." Since such plants produce germ-cells at a later period, we have here a case which requires the assumption that all or nearly all cells must contain germ-plasm.

The theory of the continuity of the germ-plasm seems to me to be still less disproved or even rendered improbable by the facts of the alternation of generations. If the germ-plasm may pass on from the egg into certain somatic cells of an individual, and if it can be further transmitted along certain lines, there is no difficulty in supposing that it may be transmitted through a second, third, or through any number of individuals produced from the former by budding. In fact, in the Hydroids, on which my theory of the continuity of the germ-plasm has been chiefly based, alternation of generations is the most important means of propagation.

II. The Significance of the Polar Bodies

We have already seen that the specific nature of a cell depends upon the molecular structure of its nucleus; and it follows from this conclusion that my theory is further, and as I believe strongly, supported, by the phenomenon of the expulsion of polar bodies, which has remained inexplicable for so long a time.

For if the specific molecular structure of a cell-body is caused and determined by the structure of the nucleoplasm, every kind of cell which is histologically differentiated must have a specific nucleoplasm. But the egg-cell of most animals, at any rate during the period of growth, is by no means an indifferent cell of the most primitive type. At such a period its cell-body has to perform quite peculiar and specific functions; it has to secrete nutritive substances of a certain chemical nature and physical constitution, and to store up this food material in such a manner that it may be at the disposal of the embryo during its development. In most cases the egg-cell also forms membranes which are often characteristic of particular species of animals. The growing egg-cell is therefore histologically differentiated: and in this respect resembles a somatic cell. It may perhaps be compared to a gland-cell, which does not expel its secretion, but deposits it within its own substance. To perform such specific functions it requires a specific cell-body, and the latter depends upon a specific nucleus. It therefore follows that the growing egg-cell must possess nucleoplasm of specific molecular structure, which directs the above mentioned secretory functions of the cell. The nucleoplasm of histologically differentiated cells may be called histogenetic nucleoplasm, and the growing egg-cell must contain such a substance, and even a certain specific modification of it. This nucleoplasm cannot possibly be the same as that which, at a later period, causes embryonic development. Such development can only be produced by true germ-plasm of immensely complex constitution, such as I have previously attempted to describe. It therefore follows that the nucleus of the egg-cell contains two kind of nucleoplasm:—germ-plasm and a peculiar modification of histogenetic nucleoplasm, which may be called ovogenetic nucleoplasm. This substance must greatly preponderate in the young egg-cell, for, as we have already seen, it controls the growth of the latter. The germ-plasm, on the other hand, can only be present in minute quantity at first, but it must undergo considerable increase during the growth of the cell. But in order that the germ-plasm may control the cell-body, or, in other words, in order that embryonic development may begin, the still preponderating ovogenetic nucleoplasm must be removed from the cell. This removal takes place in the same manner as that in which differing nuclear substances are separated during the ontogeny of the embryo: viz., by nuclear division, leading to cell-division. The expulsion of the polar bodies is nothing more than the removal of ovogenetic nucleoplasm from the egg-cell. That the ovogenetic nucleoplasm continues to

greatly preponderate in the nucleus up to the very last, may be concluded from the fact that two successive divisions of the latter and the expulsion of two polar bodies appear to be the rule. If in this way a small part of the cell-body is expelled from the egg, the extrusion must in all probability be considered as an inevitable loss, without which the removal of the ovogenetic neucloplasm cannot be effected.

III. On the Nature of Parthenogenesis

It is well known that the formation of polar bodies has been repeatedly connected with the sexuality of germ-cells, and that it has been employed to explain the phenomena of parthenogenesis. I may now perhaps be allowed to develop the views as to the nature of parthenogenesis at which I have arrived under the influence of my explanation of polar bodies.

The theory of parthenogenesis adopted by Minot and Balfour is distinguished by its simplicity and clearness, among all other interpretations which had been hitherto offered. Indeed, their explanation follows naturally and almost as a matter of course, if the assumption made by these observers be correct, that the polar body is the male part of the hermaphrodite egg-cell. An egg which has lost its male part cannot develop into an embryo until it has received a new male part in fertilization. On the other hand, an egg which does not expel its male part may develop without fertilization, and thus we are led to the obvious conclusion that parthenogenesis is based upon the non-expulsion of polar bodies. Balfour distinctly states "that the function of forming polar cells has been acquired by the ovum for the express purpose of preventing parthenogenesis."

It is obvious that I cannot share this opinion, for I regard the expulsion of polar bodies as merely the removal of the ovogenetic nucleoplasm, on which depended the development of the specific histological structure of the egg-cell. I must assume that the phenomena of maturation in the parthenogenetic egg and in the sexual egg are precisely identical, and that in both, the ovogenetic nucleoplasm must in some way be removed before embryonic development can begin.

Unfortunately the actual proof of this assumption is not so complete as might be desired. In the first place, we are as yet uncertain whether polar bodies are or are not expelled by parthenogenetic eggs; for in no single instance has such expulsion been established beyond doubt. It is true that this deficiency does not afford any support to the

explanation of Minot and Balfour, for in all cases in which polar bodies have not been found in parthenogenetic eggs, these structures are also absent from the eggs which require fertilization in the same species. But although the expulsion of polar bodies in parthenogenesis has not yet been proved to occur, we must assume it to be nearly certain that the phenomena of maturation, whether connected or unconnected with the expulsion of polar bodies, are the same in the eggs which develop parthenogenetically and in those which are capable of fertilization, in one and the same species. This conclusion depends, above all, upon the phenomena of reproduction in bees, in which, as a matter of fact, the same egg may be fertilized or may develop parthenogenetically, as I shall have occasion to describe in greater detail at a later period.

Hence when we see that the eggs of many animals are capable of developing without fertilization, while in other animals such development is impossible, the difference between the two kinds of eggs must rest upon something more than the mode of transformation of the nucleus of the germ-cell into the first segmentation nucleus. There are, indeed, facts which distinctly point to the conclusion that the difference is based upon quantitative and not qualitative relations. A large number of insects are exceptionally reproduced by the parthenogenetic method, *e. g.*, in Lepidoptera. Such development does not take place in all the eggs laid by an unfertilized female, but only in part, and generally a small fraction of the whole, while the rest die. But among the latter there are some which enter upon embryonic development without being able to complete it, and the stage at which development may cease also varies. It is also known that the eggs of higher animals may pass through the first stages of segmentation without having been fertilized. This was shown to be the case in the egg of the frog by Leuckart, in that of the fowl by Oellacher, and even in the egg of mammals by Hensen.

Hence in such cases it is not the impulse to development, but the power to complete it, which is absent. We know that force is always bound up with matter, and it seems to me that such instances are best explained by the supposition that too small an amount of that form of matter is present, which, by its controlling agency, effects the building up of the embryo by the transformation of mere nutritive material. This substance is the germ-plasm of the segmentation nucleus, and I have assumed above that it is altered in the course of ontogeny by changes which arise from within, so that when sufficient nourishment is afforded by the cell-body, each succeeding stage necessarily results from the pre-

ceding one. I believe that changes arise in the constitution of the nucleoplasm at each cell-division which takes place during the building up of the embryo, changes which either correspond or differ in the two halves of each nucleus. If, for the present, we neglect the minute amount of unchanged germ-plasm which is reserved for the formation of the germ-cells, it is clear that a great many different stages in the development of somatic nucleoplasm are thus formed, which may be denominated as stages 1, 2, 3, 4, etc., up to *n*. In each of these stages the cells differ more as development proceeds, and as the number by which the stage is denominated becomes higher. Thus, for instance, the two first segmentation spheres would represent the first stage of somatic nucleoplasm, a stage which may be considered as but slightly different in its molecular structure from the nucleoplasm of the segmentation nucleus; the first four segmentation spheres would represent the second stage; the succeeding eight spheres the third, and so on. It is clear that at each successive stage the molecular structure of the nucleoplasm must be further removed from that of the germ-plasm, and that, at the same time, the cells of each successive stage must also diverge more widely among themselves in the molecular structure of their nucleoplasm. Early in development each cell must possess its own peculiar nucleoplasm, for the further course of development is peculiar to each cell. It is only in the later stages that equivalent or nearly equivalent cells are formed in large numbers, cells in which we must also suppose the existence of equivalent nucleoplasm.

If we may assume that a certain amount of germ-plasm must be contained in the segmentation nucleus in order to complete the whole process of the ontogenetic differentiation of this substance; if we may further assume that the quantity of germ-plasm in the segmentation nucleus varies in different cases; then we should be able to understand why one egg can only develop after fertilization, while another can begin its development without fertilization, but cannot finish it, and why a third is even able to complete its development. We should also understand why one egg only passes through the first stages of segmentation and is then arrested, while another reaches a few more stages in advance, and a third develops so far that the embryo is nearly completely formed. These differences would depend upon the extent to which the germ-plasm, originally present in the egg, was sufficient for the development of the latter; development will be arrested as soon as the nucleoplasm is no longer capable of producing the succeeding stage, and is thus unable to enter upon the following nuclear division.

From a general point of view such a theory would explain many difficulties, and it would render possible an explanation of the phyletic origin of parthenogenesis, and an adequate understanding of the strange and often apparently abrupt and arbitrary manner of its occurrence. In my works on Daphnidae I have already laid especial stress upon the proposition that parthenogenesis in insects and Crustacea certainly cannot be an ancestral condition which has been transmitted by heredity, but that it has been derived from a sexual condition. In what other way can we explain the fact that parthenogenesis is present in certain species or genera, but absent in others closely allied to them; or the fact that males are entirely wanting in species of which the females possess a complete apparatus for fertilization? I will not repeat all the arguments with which I attempted to support this conclusion. Such a conclusion may be almost certainly accepted for the Daphnidae, because parthenogenesis does not occur in their still living ancestors, the Phyllopods, and especially the Estheridae. In Daphnidae the cause and object of the phyletic development of parthenogenesis may be traced more clearly than in any other group of animals. In Daphnidae we can accept the conclusion with greater certainty than in all other groups, except perhaps the Aphidae, that parthenogenesis is extremely advantageous to species in certain conditions of life; and that it has only been adopted when, and as far as, it has been beneficial; and further, that at least in this group parthenogenesis became possible and was adopted in each species as soon as it became useful. Such a result can be easily understood if it is only the presence of more or less germ-plasm which decides whether an egg is or is not capable of development without fertilization.

If we now examine the foundations of this hypothesis we shall find that we may at once accept one of its assumptions, viz., that fluctuations occur in the quantity of germ-plasm in the segmentation nucleus; for there can never be absolute equality in any single part of different individuals. As soon therefore as these fluctuations become so great that parthenogenesis is produced, it may become, by the operation of natural selection, the chief mode of reproduction of the species or of certain generations of the species. In order to place this theory upon a firm basis, we have simply to decide whether the quantity of germ-plasm contained in the segmentation nucleus is the factor which determines development; although for the present it will be sufficient if we can render this view to some extent probable, and show that it is not in contradiction with established facts.

At first sight this hypothesis seems to encounter serious difficulties. It will be objected that neither the beginning nor the end of embryonic development can possibly depend upon the quantity of nucleoplasm in the segmentation nucleus, since the amount may be continually increased by growth; for it is well known that during embryonic development the nuclear substance increases with astonishing rapidity. By an approximate calculation I found that in the egg of a Cynips the quantity of nuclear substance present at the time when the blastoderm was about to be formed, and when there were twenty-six nuclei, was even then seven times as great as the quantity which had been contained in the segmentation nucleus. How then can we imagine that embryonic development would ever be arrested from want of nuclear substance, and if such deficiency really acted as an arresting force, how then could development begin at all? We might suppose that when germ-plasm is present in sufficient quantity to start segmentation, it must also be sufficient to complete the development; for it grows continuously, and must presumably always possess a power equal to that which it possessed at the beginning, and which was just sufficient to start the process of segmentation. If at each ontogenetic stage the quantity of nucleoplasm is just sufficient to produce the following stage, we might well imagine that the whole ontogeny would necessarily be completed.

The flaw in this argument lies in the erroneous assumption that the growth of nuclear substance is, when the quality of the nucleus and the conditions of nutrition are equal, unlimited and uncontrolled. The intensity of growth must depend upon the quantity of nuclear substance with which growth and the phenomena of segmentation commenced. There must be an optimum quantity of nucleoplasm with which the growth of the nucleus proceeds most favourably and rapidly, and this optimum will be represented in the normal size of the segmentation nucleus. Such a size is just sufficient to produce, in a certain time and under certain external conditions, the nuclear substance necessary for the construction of the embryo, and to start the long series of cell-divisions. When the segmentation nucleus is smaller, but large enough to enter upon segmentation, the nuclei of the two first embryonic cells will fall rather more below the normal size, because the growth of the segmentation nucleus, during and after division will be less rapid on account of its unusually small size. The succeeding generations of nuclei will depart more and more from the normal size in each respective stage, because they do not pass into a resting stage during embryonic

development, but divide again immediately after their formation. Hence nuclear growth would become less vigorous as the nuclei fell more and more below the optimum size, and at last a moment would arrive when they would be unable to divide, or would be at least unable to control the cell-body in such a manner as to lead to its division.

The first event of importance for embryonic development is the maturation of the egg, *i. e.*, the transformation of the nucleus of the germ-cell into a nuclear spindle and the removal of the ovogenetic nucleoplasm by the separation of polar bodies, or by some analogous process. There must be some cause for this separation, and I have already tried to show that it may lie in the quantitative relations which obtain between the two kinds of nucleoplasm contained in the nucleus of the egg. I have suggested that the germ-plasm, at first small in quantity, undergoes a gradual increase, so that it can finally oppose the ovogenetic nucleoplasm. I will not further elaborate this suggestion, for the ascertained facts are insufficient for the purpose. But the appearances witnessed in nuclear division indicate that there are opposing forces, and that such a contest is the motive cause of division; and Roux may be right in referring the opposition to electrical forces. However this may be, it is perfectly certain that the development of this opposition is based upon internal conditions arising during growth in the nucleus itself. The quantity of nuclear thread cannot by itself determine whether the nucleus can or cannot enter upon division; if so, it would be impossible for two divisions to follow each other in rapid succession, as is actually the case in the separation of the two polar bodies, and also in their subsequent division. In addition to the effects of quantity, the internal conditions of the nucleus must also play an important part in these phenomena. Quantity alone does not necessarily produce nuclear division, or the nucleus of the egg would divide long before maturation is complete, for it contains much more nucleoplasm than the female pronucleus, which remains in the egg after the expulsion of the polar bodies, and which is in most cases incapable of further division. But the fact that segmentation begins immediately after the conjugation of male and female pronuclei, also shows that quantity is an essential requisite. The effect of fertilization has been represented as analogous to that of the spark which kindles the gunpowder. In the latter case an explosion ensues, in the former segmentation begins. Even now many authorities are inclined to refer the polar repulsion manifested in the nuclear division which immediately follows

fertilization, to the antagonism between male and female elements. But, according to the important discoveries of Flemming and van Beneden, the polar repulsion in each nuclear division is not based on the antagonism between male and female loops, but depends upon the antagonism and mutual repulsion between the two halves of the same loop. The loops of the father and those of the mother remain together and divide together throughout the whole ontogeny.

What can be the explanation of the fact that nuclear division follows immediately after fertilization, but that without fertilization it does not occur in most cases? There is only one possible explanation, viz., the fact that the quantity of the nucleus has been suddenly doubled, as the result of conjugation. The difference between the male and female pronuclei cannot serve as an explanation, even though the nature of this difference is entirely unknown, because polar repulsion is not developed between the male and female halves of the nucleus, but within each male and each female half. We are thus forced to conclude that increase in the quantity of the nucleus affords an impulse for division, the disposition towards it being already present. It seems to me that this view does not encounter any theoretical difficulties, and that it is an entirely feasible hypothesis to suppose that, besides the internal conditions of the nucleus, its quantitative relation to the cell-body must be taken into especial account. It is imaginable, or perhaps even probable, that the nucleus enters upon division as soon as its idioplasm has attained a certain strength, quite apart from the supposition that certain internal conditions are necessary for this end. As above stated, such conditions may be present, but division may not occur because the right quantitative relation between nucleus and cell-body, or between the different kinds of nuclear idioplasm has not been established. I imagine that such a quantitative deficiency exists in an egg which, after the expulsion of the ovogenetic nucleoplasm in the polar bodies, requires fertilization in order to begin segmentation. The fact that the polar bodies were expelled proves that the quantity of the nucleus was sufficient to cause division, while afterwards it was no longer sufficient to produce such a result.

This suggestion will be made still clearer by an example. In *Ascaris megalocephala* the nuclear substance of the female pronucleus forms two loops, and the male pronucleus does the same; hence the segmentation nucleus contains four loops, and this is also the case with the first segmentation spheres. If we suppose that in embryonic develop-

ment the first nuclear division requires such an amount of nuclear substance as is necessary for the formation of four loops,—it follows that an egg, which can only form two or three loops from its nuclear reticulum, would not be able to develop parthenogenetically, and that not even the first division would take place. If we further suppose that, while four loops are sufficient to start nuclear division, these loops must be of a certain size and quantity in order to complete the whole ontogeny (in a certain species), it follows that eggs possessing a reticulum which contains barely enough nuclear substance to divide into four segments, would be able to produce the first division and perhaps also the second and third, or some later division, but that at a certain point during ontogeny, the nuclear substance would become insufficient, and development would be arrested. This will occur in eggs which enter upon development without fertilization, but are arrested before its completion. One might compare this retardation leading to the final arrest of development, to a railway train which is intended to meet a number of other trains at various junctions, and which can only travel slowly because of some defect in the engine. It will be a little behind time at the first junction, but it may just catch the train, and it may also catch the second or even the third; but it will be later at each successive junction, and will finally arrive too late for a certain train; and after that it will miss all the trains at the remaining junctions. The nuclear substance grows continuously during development, but the rate at which it increases depends upon the nutritive conditions together with its initial quantity. The nutritive changes during the development of an egg depend upon the quantity of the cell-body which was present at the outset, and which cannot be increased. If the quantity of the nuclear substance is rather too small at the beginning, it will become more and more insufficient in succeeding stages, as its growth becomes less vigorous, and differs more from the standard it would have reached if the original quantity had been normal. Consequently it will gradually fall more and more short of the normal quantity, like the train which arrives later and later at each successive junction, because its engine, although with the full pressure of steam, is unable to attain the normal speed.

It will be objected that four loops cannot be necessary for nuclear division in *Ascaris,* since such division takes place in the formation of the polar bodies, resulting in the appearance of the female pronucleus with only two loops. But this fact only shows that the quantity of nuclear substance necessary for the formation of four loops is not neces-

sary for all nuclear divisions; it does not disprove the assumption that such a quantity is required for the division of the segmentation nucleus. In addition to these considerations we must not leave the substance of the cell-body altogether out of account, for, although it is not the bearer of the tendencies of heredity, it must be necessary for every change undergone by the nucleus, and it surely also possesses the power of influencing changes to a large extent. There must be some reason for the fact that in all animal eggs with which we are acquainted, the nucleus moves to the surface of the egg at the time of maturation, and there passes through its well known transformation. It is obvious that it is there subjected to different influences from those which would have acted upon it in the center of the cell-body, and it is clear that such an unequal cell-division as takes place in the separation of the polar bodies could not occur if the nucleus remained in the center of the egg.

This explanation of the necessity for fertilization does not exclude the possibility that, under certain circumstances, the substance of the egg-nucleus may be larger, so that it is capable of forming four loops. Eggs which thus possess sufficient nucleoplasm, viz., germ-plasm, for the formation of the requisite four loops of normal size (namely, of the size which would have been produced by fertilization), can and must develop by the parthenogenetic method.

Of course the assumption that four loops must be formed has only been made for the sake of illustration. We do not yet know whether there are always exactly four loops in the segmentation nucleus. I may add that, although the details by which these considerations are illustrated are based on arbitrary assumptions, the fundamental view that the development of the egg depends, *ceteris paribus,* upon the quantity of nuclear substance, is certainly right, and follows as a necessary conclusion from the ascertained facts. It is not unlikely that such a view may receive direct proof in the results of future investigations. Such proof might, for instance, be forthcoming if we were to ascertain, in the same species, the number of loops present in the segmentation nucleus of fertilization, as compared with those present in the segmentation nucleus of parthenogenesis.

The reproductive process in bees will perhaps be used as an argument against my theory. In these insects the same egg will develop into a female or male individual, according as fertilization has or has not taken place, respectively. Hence one and the same egg is capable of fertilization, and also of parthenogenetic development, if if it does

not receive a spermatozoon. It is in the power of the queen-bee to produce male or female individuals: by an act of will she decides whether the egg she is laying is to be fertilized or unfertilized. She "knows beforehand" whether an egg will develop into a male or a female animal, and deposits the latter kind in the cells of queens and workers, the former in the cells of drones. It has been shown by the discoveries of Leuckart and von Siebold that all the eggs are capable of developing into male individuals, and that they are only transformed into "female eggs" by fertilization. This fact seems to be incompatible with my theory as to the cause of parthenogenesis, for if the same egg, possessing exactly the same contents, and above all the same segmentation nucleus, may develop sexually or parthenogenetically, it appears that the power of parthenogenetic development must depend on some factor other than the quantity of germ-plasm.

Although this appears to be the case, I believe that my theory encounters no real difficulty. I have no doubt whatever that the same egg may develop with or without fertilization. From a careful study of the numerous excellent investigations upon this point which have been conducted in a particularly striking manner by Bessels (in addition to the observers quoted above), I have come to the conclusion that the fact is absolutely certain. It must be candidly admitted that the same egg will develop into a drone when not fertilized, or into a worker or queen when fertilized. One of Bessels' experiments is sufficient to prove this assertion. He cut off the wings of a young queen and thus rendered her incapable of taking "the nuptial flight." He then observed that all the eggs which she laid developed into male individuals. This experiment was made in order to prove that drones are produced by unfertilized eggs; but it also proves that the assertion mentioned above is correct, for the eggs which ripen first and are therefore first laid, would have been fertilized had the queen been impregnated. The supposition that, at certain times, the queen produces eggs requiring fertilization, while at other times her eggs develop parthenogenetically, is quite excluded by this experiment; for it follows from it that the eggs must all be of precisely the same kind, and that there is no difference between the eggs which require fertilization and those which do not.

But does it therefore follow that the quantity of germ-plasm in the segmentation nucleus is not the factor which determines the beginning of embryonic development? I believe not. It can be very well imagined that the nucleus of the egg, having expelled the ovogenetic nucleo-

plasm, may be increased to the size requisite for the segmentation nucleus in one of two ways: either by conjugation with a sperm-nucleus, or by simply growing to double its size. There is nothing improbable in this latter assumption, and one is even inclined to inquire why such growth does not take place in all unfertilized eggs. The true answer to this question must be that nature pursues the sexual method of reproduction, and that the only way in which the general occurrence of parthenogenesis could be prevented was by the production of eggs which remained sterile unless they were fertilized. This was effected by a loss of the capability of growth on the part of the egg-nucleus after it had expelled the ovogenetic nucleoplasm.

The case of the bee proves in a very striking manner that the difference between eggs which require fertilization, and those which do not, is not produced until after the maturation of the egg and the removal of the ovogenetic nucleoplasm. The increase in the quantity of the germ-plasm cannot have taken place at any earlier period, or else the nucleus of the egg would always start embryonic development by itself, and the egg would probably be incapable of fertilization. For the relation between egg-nucleus and sperm-nucleus is obviously based upon the fact that each of them is insufficient by itself, and requires completion. If such completion had taken place at an early stage the egg-nucleus would either cease to exercise any attractive force upon the sperm-nucleus, or else conjugation would be effected, as in Fol's interesting experiments upon fertilization by many spermatozoa; and, as in these experiments, malformation of the embryo would result. In Daphnidae I believe I have shown that the summer eggs are not only developed parthenogenetically, but also that they are never fertilized; and the explanation of this incapacity for fertilization may perhaps be found in the fact that their segmentation nucleus is already formed.

We may therefore conclude that, in bees, the nucleus of the egg, formed during maturation, may either conjugate with the sperm-nucleus, or else if no spermatozoon reaches the egg may, under the stimulus of internal causes, grow to double its size, thus attaining the dimensions of the segmentation nucleus. For our present purpose we may leave out of consideration the fact that in the latter case the individual produced is a male, and in the former case a female.

ROBERT KOCH

ROBERT KOCH was born at Klausthal, Hanover, Germany, Dec. 11, 1843, and graduated from the University of Göttingen in 1866. He was assistant surgeon to the General Hospital at Hamburg for a time and afterwards practiced medicine at Langenhagen, Kackwitz, and Wollenstein, where he lived from 1872 to 1880. It was here that he began his researches in bacteriology. His investigations on the ætiology of anthrax, published in 1876, and his important study of the ætiology of anthrax published in 1878 placed bacteriology on a scientific basis. In 1880 Dr. Koch went to Berlin to accept a position as chief of the Sanitary Institute of Berlin; here he carried on his studies of the *contagia* of consumption and cholera. Koch claims that each disease is caused by a specific micro-organism. In 1882 he announced his discovery of the tubercle bacillus. In order to reach his conclusions he invented new microscopical appliances, and new methods of staining specimens in order to make those micro-organisms visible, thus making a very important advance in microscopy. In 1883 Dr. Koch published a method of preventive inoculation against anthrax. In the same year the German Government sent him to Egypt and India to investigate cholera, where he discovered the cholera bacillus. On his return to Germany in 1884 he was generously rewarded by the Government. He went to France as cholera commissioner early in 1885 and later was appointed Professor of the Medical Faculty of the University of Berlin, Director of the Prussian Board of Health, and Director of the Hygienic Institute of Berlin. He published a paper on the prophylaxis of infectious diseases in the army in 1888. In 1890 he announced the discovery of the bacillus of consumption.

In 1896 he visited South Africa to study the cattle plague. In 1901 Dr. Koch attended the British Congress on Tuberculosis held in London and presided over by Lord Lister, where he read an address on "The Combating of Tuberculosis in the Light of the Experience Gained in the Successful Combating of Other Infectious Diseases." He produced what was held by the Congress to be satisfactory evidence that

human tuberculosis was not transmissible to animals; but there was some hesitation in accepting his conclusion that bovine tuberculosis could not be transmitted to the human subject by infected meat, milk, etc.

THEORY OF BACTERIA

I am well aware that the investigations above described are very imperfect. It was necessary, in order to have time for those parts of the investigation which seemed the most important and essential, to omit the examination of many organs, such as the brain, heart, retina, etc., which ought not to pass unnoticed in researches on infective diseases. For the same reason no record was kept of the temperature, although this would undoubtedly have yielded most interesting results. I have intentionally refrained from entering into details of morbid anatomy, as only the etiology interested me, and as I did not feel qualified to undertake a study of the morbid anatomy of traumatic infective diseases. I must therefore leave this part of the investigation to those who are better able to undertake it.

Nevertheless I consider that the results of my researches are sufficiently definite to enable me to deduce from them some well founded conclusions.

In this summary I shall, however, confine myself to the most obvious conclusions. It has indeed of late become too common to draw the most sweeping conclusions as to infective diseases in general from the most unimportant observations on bacteria. I shall not follow this custom, although the material at my command would furnish rich food for meditation. For the longer I study infective diseases the more am I convinced that generalisations of new facts are here a mistake, and that every individual infective disease or group of closely allied diseases must be investigated for itself.

As regards the artificial traumatic infective diseases observed by me, the conditions which must be established before their parasitic nature can be proved, we completely fulfilled in the case of the first five, but only partially in that of the sixth. For the infection was produced by such small quantities of fluid (blood, serum, pus, etc.,) that the result cannot be attributed to a merely chemical poison.

In the materials used for inoculation bacteria were without exception present, and in each disease a different and well marked form of organism could be demonstrated.

At the same time, the bodies of those animals which died of the artificial traumatic infective diseases contained bacteria in such numbers that the symptoms and the death of the animals were sufficiently explained. Further, the bacteria found were identical with those which were present in the fluid used for inoculation, and a definite form of organisms corresponded in every instance to a distinct disease.

These artificial traumatic infective diseases bear the greatest resemblance to human traumatic infective diseases, both as regards their origin from putrid substances, their course, and the result of post-mortem examination. Further, in the first case, just as in the last, the parasitic organisms could be only imperfectly demonstrated by the earlier methods of investigation; not till an improved method of procedure was introduced was it possible to obtain complete proof that they were parasitic diseases. We are therefore justified in assuming that human traumatic infective diseases will in all probability be proved to be parasitic when investigated by these improved methods.

On the other hand, it follows from the fact that a definite pathogenic bacterium, e. g., the septicæmic bacillus, cannot be inoculated on every variety of animal (a similar fact is also true with regard to the bacillus anthracis); that the septicæmia of mice, rabbits, and man are not under all circumstances produced by the same bacterial form. It is of course possible that one or other of the bacteric forms found in animals also play a part in such diseases in the human subject. That, however, must be especially demonstrated for each case; *a priori* one need only expect that bacteria are present; as regards form, size and conditions of growth, they may be similar, but not always the same, even in what appear to be similar diseases in different animals.

Besides the pathogenic bacteria already found in animals there are no doubt many others. My experiments refer only to those diseases which ended fatally. Even these are in all probability not exhausted in the six forms mentioned. Further experiments on many different species of animals, with the most putrid substances and with every possible modification in the method of application, will doubtless bring to light a number of other infective diseases, which will lead to further conclusions regarding infective diseases and pathogenic bacteria.

But even in the small series of experiments which I was able to carry out, one fact was so prominent that I must regard it as constant, and, as it helps to remove most of the obstacles to the admission of the existence of a centagium vivum for traumatic infective diseases, I look

on it as the most important result of my work. I refer to the differences which exist between pathogenic bacteria and to the constancy of their characters. A distinct bacteric form corresponds, as we have seen, to each disease, and this form always remains the same, however often the disease is transmitted from one animal to another. Further, when we succeed in reproducing the same disease *de novo* by the injection of putrid substances, only the same bacteric form occurs which was before found to be specific for that disease.

Further, the differences between these bacteria are as great as could be expected between particles which border on the invisible. With regard to these differences, I refer not only to the size and form of the bacteria, but also to the conditions of their growth, which can be best recognized by observing their situation and grouping. I therefore study not only the individual alone, but the whole group of bacteria, and would, for example, consider a micrococcus which in one species of animal occurred only in masses (i. e., in a zooglæa form), as different from another which in the same variety of animal, under the same conditions of life, was only met with as isolated individuals. Attention must also be paid to the physiological effect, of which I scarcely know a more striking example than the case of the bacillus and the chain-like micrococcus growing together in the cellular tissue of the ear; the one passing into the blood and penetrating into the white blood corpuscles, the other spreading out slowly into the tissues in its vicinity and destroying everything around about; or again, the case of the septicæmic and pyæmic micrococci of the rabbit in their different relations to the blood; or lastly, the bacilli only extending over the surface of the aural cartilage in the erysipetalous disease, as contrasted with the bacillus anthracis, likewise inoculated on the rabbit's ear, but quickly passing into the blood.

As, however, there corresponds to each of the diseases investigated a form of bacterium distinctly characterized by its physiological action, by its conditions of growth, size, and form, which, however often the disease be transmitted from one animal to another, always remains the same and never passes over into another form, e. g., from the spherical to the rod shaped, we must in the meantime regard these different forms of pathogenic bacteria as distinct and constant species.

This is, however, an assertion that will be much disputed by botanists, to whose special province this subject really belongs.

Amongst those botanists who have written against the subdivision

of bacteria into species, is Nägeli, who says, "I have for ten years examined thousands of different forms of bacteria, and I have not yet seen any absolute necessity for dividing them even into two distinct species."

Brefeld also states that he can only admit the existence of specific forms justifying the formation of distinct species when the whole history of development has been traced by cultivation from spore to spore in the most nutritive fluids.

Although Brefeld's demand is undoubtedly theoretically correct, it cannot be made a *sine qua non* in every investigation on pathogenic bacteria. We should otherwise be compelled to cease our investigations into the etiology of infective diseases till botanists have succeeded in finding out the different species of bacteria by cultivation and development from spore to spore. It might then very easily happen that the endless trouble of pure cultivation would be expended on some form of bacterium which would finally turn out to be scarcely worthy of attention. In practice only the opposite method can work. In the first place certain peculiarities of a particular form of bacterium different from those of other forms, and in the second place its constancy, compel us to separate it from others less known and less interesting, and provisionally to regard it as a species. And now, to verify this provisional supposition, the cultivation from spore to spore may be undertaken. If this succeeds under conditions which cut out all sources of fallacy, and of it furnishes a result corresponding to that obtained by the previous observations, then the conclusions which were drawn from these observations and which led to its being ranked as a distinct species must be regarded as valid.

On this, which as it seems to me is the only correct practical method, I take my stand, and, till the cultivation of bacteria from spore to spore shows that I am wrong, I shall look on pathogenic bacteria as consisting of different species.

In order, however, to show that I do not stand alone in this view, I shall here mention the opinion of some botanists who have already come to a similar conclusion.

Cohn states that, in spite of the fact that many dispute the necessity of separating bacteria into genera or species, he must nevertheless adhere to the method as yet followed by him, and separate bacteria of a different form and fermenting power from each other, so long as complete proof of their identity is not given.

From his investigations on the effects of different temperatures and

of desiccation on the development of bacterium termo, Eidam came to the conclusion that different forms of bacteria require different conditions of nutriment, and that they behave differently towards physical and chemical influences. He regards these facts as a further proof of the necessity of dividing organisms into distinct species.

I shall bring forward another reason to show the necessity of looking on the pathogenic bacteria which I have described as distinct species. The greatest stress, in investigations on bacteria, is justly laid on the so-called pure cultivations, in which only one definite form of bacterium is present. This evidently arises from the view that if, in a series of cultivations, the same form of bacterium is always obtained, a special significance must attach to this form: it must indeed be accepted as a constant form, or in a word as a species. Can, then, a series of pure cultivations be carried out without admixture of other bacteria? It can in truth be done, but only under very limited conditions. Only such bacteria can be cultivated pure, with the aids at present at command, which can always be known to be pure, either by their size and easily recognizable form, as the bacillus anthracis, or by the production of a characteristic coloring matter as the pigment bacteria. When, during a series of cultivations, a strange species of bacteria has by chance got in, as may occasionally happen under any circumstances, it will in these cases be at once observed, and the unsuccessful experiment will be thrown out of the series without the progress of the investigation being thereby necessarily interfered with.

But the case is quite different when attempts are made to carry out cultivations of very small bacteria, which, perhaps, cannot be distinguished at all without staining; how are we then to discover the occurrence of contamination? It is impossible to do so, and therefore all attempts at pure cultivation in apparatus, however skillfully planned and executed, must, as soon as small bacteria with but little characteristic appearances are dealt with, be considered as subject to unavoidable sources of fallacy, and in themselves inconclusive.

But nevertheless a pure cultivation is possible, even in the case of the bacteria which are smallest and most difficult to recognise. This, however, is not conducted in cultivation apparatus, but in the animal body. My experiments demonstrate this. In all the cases of a distinct disease, e. g., of septicæmia of mice, only the small bacilli were present, and no other form of bacterium was ever found with it, unless in the case where that causing the tissue gangrene was intentionally inoculated

at the same time. In fact, there exists no better cultivation apparatus for pathogenic bacteria than the animal body itself. Only a very limited number of bacteria can grow in the body, and the penetration of organisms into it is so difficult that the uninjured living body may be regarded as completely isolated with respect to other forms of bacteria than those intentionally introduced. It is quite evident, from a careful consideration of the two diseases produced in mice-septicæmia and gangrene of the tissue—that I have succeeded in my experiments in obtaining a pure cultivation. In the putrefying blood, which was the cause of these two diseases, the most different forms of bacteria were present, and yet only two of these found in the living mouse the conditions necessary for their existence. All the others died, and these two alone, a small bacillus and a chain-like micrococcus, remained and grew. These could be transferred from one animal to another as often as was desired, without suffering any alteration in their characteristic form, in their specific physiological action and without any other variety of bacteria at any time appearing. And further, as I have demonstrated, it is quite in the power of the experimenter to separate these two forms of bacteria from each other. When the blood in which only the bacilli are present is used, these alone are transmitted, and thenceforth are obtained quite pure; while on the other hand, when a field mouse is inoculated with both forms of bacteria, the bacilli disappear, and the micrococcus can be then cultivated pure. Doubtless an attempt to unite these two forms again in the same animal by inoculation would have been successful. In short, one has it completely in one's power to cultivate several varieties of bacteria together, to separate them from each other, and eventually to combine them again. Greater demands can hardly be made on a pure cultivation, and I must therefore regard the successive transmission of artificial infective diseases as the best and surest method of pure cultivation. And it can further claim the same power of demonstrating the existence of specific forms of bacteria, as must be conceded to any faultless cultivation experiments.

From the fact that the animal body is such an excellent apparatus for pure cultivation, and that, as we have seen, when the experiments are properly arranged and sufficient optical aids used, only one specific form of bacterium can be found in each distinct case of artificial traumatic infective disease, we may now further conclude that when, in examining a traumatic infective disease, several different varieties of bacteria are found, as e. g., chains of small granules, rods, and long, oscil-

lating threads—such as were seen together by Coze and Feltz in the artificial septicæmia of rabbits—we have to do either with a combined infective disease,—that is, not a pure one,—or, what in the case cited is more probable, an inexact and inaccurate observation. When, therefore, several species of bacteria occur together in any morbid process, before definite conclusions are drawn as to the relations of the disease in question to the organisms, either proof must be furnished that they are all concerned in the morbid process, or an attempt must be made to isolate them and to obtain a true pure cultivation. Otherwise we cannot avoid the objection that the cultivation was not pure, and therefore not conclusive. I shall only briefly refer to a further necessary consequence of the admission of the existence of different species of pathogenic bacteria. The number of the species of these bacteria is limited; for, of the numerous diverse forms present in putrid fluids, one or but few can in the most favorable cases develop in the animal body. Those which disappear are, for that species of animal at least, not pathogenic bacteria. If, however, as follows from the foregoing, there exist hurtful and harmless bacteria, experiments performed on animals with the latter, e. g., with bacterium termo, prove absolutely nothing for or against the behavior of the former—the pathogenic—forms. But almost all the experiments of this nature have been carried out with the first mixture of different species of bacteria which came to hand without there being any certainty that pathogenic bacteria were in reality present in the mixture. It is therefore evident that none of these experiments can be regarded as furnishing evidence of any value for or against the parasitic nature of infective diseases.

In all my experiments, not only have the form and size of the bacteria been constant, but the greatest uniformity in their actions on the animal organisms has been observed, though no increase of virulence, as described by Coze and Feltz, Davaine, and others. This leads me to make some remarks on the supposed law of the increasing virulence of blood when transmitted through successive animals, discovered or confirmed by the investigators just named.

The discovery of this law has as is well known, been received with great enthusiasm, and it has excited no little interest owing to its intimate bearing on the doctrine of natural selection (Anpassung and Vererbung). Some investigators, who are in other things very exact, have allowed themselves to be blinded by the seductive theory that the insignificant action of a single putrefactive bacterium may, by continued

natural selection in passing from animal to animal, be increased in virulence till it becomes deadly though a drop of the infective liquid be diluted in a quadrillion times. They have founded thereon the most beautiful practical applications, not suspecting that the bacteria in question have never been certainly demonstrated.

The original works of Coze and Feltz, as also that of Davaine, are not at my disposal for reference; and I cannot therefore enter into a complete criticism of them. So far, however, as I can gather from the references accessible to me, especially from the detailed notices in Virchow and Hirch's "Jahnesbericht," no complete proof that the virulence of septicæmic blood increases from generation to generation seems to have been furnished. Apparently blood more and more diluted was injected, and astonishment was felt when this always acted, the effect being then ascribed to its increasing virulence. But controlling experiments to ascertain whether the septicæmic blood were not already as virulent in the second and third generations as in the twenty-fifth, do not seem to have been made. My experiments so far support and are in accordance with those of Coze, Feltz, and Davaine in that for the first infection of an animal relatively large quantities of putrid fluid are necessary; but in the second generation, or at the latest in the third, the full virulence was attained, and afterwards remained constant.

Of my artificial infective diseases the septicæmia of the mouse has the greatest correspondence with the artificial septicæmia described by Davaine. If we were to experiment with this disease in the same manner as Davaine experimented, we would, if no controlling experiments were employed, find the same increase in virulence of the disease. It would only be necessary to use blood in slowly decreasing quantities in order to obtain in this way any progressive increase of the virulence that might be desired. I, however, took from the second or third animal the smallest possible quantity of material for inoculation, and thus arrived more quickly at the greatest degree of virulence. Till, therefore, I am assured that, in the septicæmia observed by Davaine, such controlling experiments were made, I can only look on an increase in virulence as holding good for the earlier generations. In order to explain this we do not, however, require to have recourse to the magical wand of natural selection; a feasible explanation can be very naturally furnished. Let us take again the septicæmia of mice, as being the most suitable example.

If two drops of putrefying blood be injected into such an animal

there is introduced not only a number of totally distinct species of bacteria, but also a certain amount of dissolved putrid poison (sepsin), not sufficient to produce a fatal effect, but yet certainly not without influence on the health of the animal. Different factors must therefore be considered as affecting the health of the animal. On the one hand there is the dissolved poison, on the other the different species of bacteria, of which, however, perhaps only two, as in the example before us, can multiply in the body of the mouse and there exert a continuous noxious influence. Only one of these two species can penetrate into the blood, and if the blood alone be used for further inoculations, only this one variety will come victorious out of the battle for existence. The further development of the experiment depends entirely on the quantity of the putrid poison, and on the relation of the two forms of bacteria to each other in point of numbers. If one injects a large amount of septic poison and a large number of that variety of bacteria which increases locally (in this case the chain-like micrococci causing the gangrene of the tissue), but only a very small number of the bacteria which pass into the blood (here the bacilli), the first animal experimented on will die, as a result of the preponderation influence of the first two factors before many bacilli can have got into the blood and multiplied there. Of the blood of this first animal, containing, as it does, proportionately very few bacilli, one-fifth to one-tenth of a drop must be inoculated in order to convey the disease with certainty. In the second animal, however, only the bacilli are introduced, and these develop undisturbed in the blood. For the infection of the third animal the smallest quantity of this blood which can produce an effect is then sufficient, and after this third generation the virulence of the blood remains uniform.

We may also imagine another case in which the increase of the virulence may go on through more than two generations without any modification resulting from natural selection and transmission from animal to animal. This would take place if several species of bacteria capable of passing into the blood were introduced into the animal at the first injection. Let us suppose, for example, that in the same putrefying blood which served for the foregoing experiment, the bacilli of anthrax were also present, there would then be contained in the blood of the first animal not only the septicæmic bacillus, but also bacillus anthracis, and of each only a small number; of the anthrax bacillus there would be even fewer than of the other, because in mice they are deposited chiefly in the spleen, lungs, etc.; while in the blood of the heart they

are, even in the most favorable cases, only sparsely distributed. On the other hand, the anthrax bacilli have this advantage, that, provided they be inoculated in considerable numbers, they kill even within twenty hours, while the septicæmic bacilli only destroy life after fifty hours. In the blood of the second animal, therefore, both species of bacilli would be present in larger numbers than in the first, although not yet so numerous as if either organism had been inoculated singly. Hence a larger quantity of blood is necessary to ensure transmission to a third animal. Perhaps this might be the case even in the fourth generation, till finally one or other variety of bacillus would alone be present in the blood injected. Probably this would be the septicæmic bacillus.

In this way the experiments of Coze, Feltz, and Davaine may admit of simple explanation and be brought into harmony with my results.

LOUIS PASTEUR

LOUIS PASTEUR was born at Dôle, France, December 27, 1822. His father was a tanner. In 1825 the family moved to Arbois, where Pasteur was sent to college. Later he attended Besançon, where he took his bachelor's degree. He now went to the Ecole Normale to continue his studies in chemistry, and three years later he was appointed assistant professor there. His first important scientific work was done in showing the asymmetry of molecules, but this is not the field in which he made his greatest reputation. In 1863 he took up the question of fermentation and showed that it is due to the growth of bacteria—microscopic plants—and soon afterward proved the same fact to be the cause of putrefaction. This immediately led to Lister's conception of antiseptic surgery and dealt a fatal blow to the doctrine of spontaneous generation.

In 1865 Pasteur discovered the bacillus which was the cause of the silkworm disease.

Davaine had discovered the bacillus of anthrax in 1863, and Pasteur took up the question of inoculation on the theoretical principle of small-pox vaccination. After passing the germs successively through a number of animals, he found that a few drops of blood from an infected

animal constituted a lymph which, if injected gradually and in small enough quantities, would cause only a mild attack of anthrax, which would act as a preventive thereafter. This is the great principle of inoculation with which scientists are to-day attempting to combat the infectious diseases. Pasteur himself applied it with great success to the cure of hydrophobia in 1880-1885. He found that the inoculation acted as an almost certain preventive even after patients were bitten by a mad dog.

He died September 28, 1895.

The extracts first given below will give some idea of his work on fermentation. His account of his work on hydrophobia follows later.

ON FERMENTATION

We maintain, adducing incontestable experimental evidence in support of our theory, that living, organized ferments spring only from similar organisms likewise endowed with life; and that the germs of these ferments exist in a state of suspension in the air, or on the exterior surface of objects. M. Fremy asserts that these ferments are formed by the force of hemi-organisms acting on albuminous substances, in contact with the air. We may put the matter more precisely by two examples:—

Wine is produced by a ferment, that is to say, by minute, vegetative cells which multiply by budding. According to us, the germs of these cells abound in autumn on the surface of grapes and on the woody parts of their branches; and the proofs which we have given of this fact are as clear as any evidence can be. According to M. Fremy, the cells of ferment are produced by spontaneous generation, that is to say, by the transformation of nitrogenous substances contained in the juice of the grape, as soon as that juice is brought into contact with the air.

Again, blood flows from a vein; it putrefies, and in a very short time swarms with bacteria or virbios. According to us the germs of these bacteria and virbios have been introduced by particles of dust floating in the air or derived from the surface of objects, possibly the body of the wounded animal, or the vessels employed, or a variety of other objects. M. Fremy, on the other hand, asserts that these bacteria or virbios are produced spontaneously, because the albumin, and the fibrin of the blood themselves possess a semi-organization, which causes

them, when in contact with the air, to change spontaneously into these marvelously active minute beings.

Has M. Fremy given any proof of the truth of his theory? By no manner of means; he confines himself to asserting that things are as he says they are. He is constantly speaking of hemi-organism and its effects, but we do not find his affirmations supported by a single experimental proof. There is, nevertheless, a very simple means of testing the truth of the theory of hemi-organism; and on this point M. Fremy and ourselves are quite at one. This means consists in taking a quantity of grape juice, wine, blood, etc., from the very interior of the organs which contain those liquids, with the necessary precautions to avoid contact with the particles of dust in suspension in the air or spread over objects. According to the hypothesis of M. Fremy, these liquids must of necessity ferment in the presence of pure air. According to us, the very opposite of this must be the case. Here, then, is a crucial experiment of the most decisive kind for determining the merits of the rival theories, a criterion, moreover, which M. Fremy perfectly admits. In 1863, and again in 1872, we published the earliest experiments that were made in accordance with this decisive method. The result was as follows: The grape juice did not ferment in vessels full of air, air deprived of its particles of dust—that is to say, it did not produce any of the ferments of wine; the blood did not putrefy—that is to say, it yielded neither bacteria nor virbios; urine did not become ammoniacal—that is to say, it did not give rise to any organism; in a word, the origin of life manifested itself in no single instance.

The hemi-organism hypothesis is, therefore, absolutely untenable, and we have no doubt that our learned friend will eventually declare as much before the Academy, since he has more than once publicly expressed his readiness to do so as soon as our demonstrations appear convincing to him. How can he resist the evidence of such facts and proofs? Persistence in such a course can benefit nobody, but it may depreciate the dignity of science in general esteem. It would gratify us extremely to find the rigorous exactness of our studies on this subject acknowledged by M. Fremy, and regarded by that gentleman with the same favour bestowed upon it everywhere abroad. It may be doubted if there exists at the present day a single person beyond the Rhine who believes in the correctness of Liebig's theory, of which M. Fremy's hemi-organism is merely a variation. If M. Fremy still hesitates to accept our demonstrations, the observations of Mr. Tyndall may effect his conversion.

London, February 16, 1876.

"Dear Mr. Pasteur:

"For the first time in the history of science, we are justified in cherishing confidently the hope that, as far as epidemic diseases are concerned, medicine will soon be delivered from empiricism, and placed on a real scientific basis; when that great day shall come, humanity will, in my opinion, recognize the fact that the greatest part of its gratitude will be due to you.

"Believe me, ever very faithfully yours,

"JOHN TYNDALL."

We need scarcely say that we read this letter with liveliest gratification, and were delighted to learn that our studies had received the support of one renowned in the scientific world alike for rigorous accuracy in his experiments as for the lucid and picturesque clearness of all his writings. The reward as well as the ambition of the man of science consists in earning the approbation of his fellow-workers, or that of those he esteems masters.

Mr. Tyndall has observed this remarkable fact, that in a box, the sides of which are coated with glycerine, and the dimensions of which may be variable and of considerable size, all the particles of dust floating in the air inside fall and adhere to the glycerine in the course of a few days. The air in the case is then as pure as that in our double-necked flasks. Moreover, a transmitted ray of light will tell us the moment when this purity is obtained. Mr. Tyndall has proved, in fact, that to the eye rendered sensitive by remaining in darkness for a little while, the course of the ray is visible as long as there are any floating particles of dust capable of reflecting or diffusing light, and that, on the other hand, it becomes quite obscure and invisible to the same eye as soon as the air has deposited all its solid particles. When it has done this, which it will do very quickly—in two or three days, if we employ one of the boxes used by Mr. Tyndall—it has been proved that any organic infusions whatever may be preserved in the case without undergoing the least putrefactive change, or without producing bacteria.

On the other hand, bacteria will swarm in similar infusions, after an interval of from two to four days, if the vessels which contain them are exposed to the air by which the cases are surrounded. Mr. Tyndall can drop into his boxes, at any time he wishes, some blood from a vein or an artery of an animal, and show conclusively that such blood will not, under these circumstances, undergo any putrefactive change.

Mr. Tyndall concludes his work with a consideration of the probable application of the results given in his paper to the etiology of contagious diseases. We share his views on this subject entirely, and we

are obliged to him for having recalled to mind the following statement from our *Studies on the Silkworm Disease:* "Man has it in his power to cause parasitic diseases to disappear off the surface of the globe, if, as we firmly believe, the doctrine of spontaneous generation is a chimera."

INOCULATION FOR HYDROPHOBIA

Gentlemen:—Your Congress meetings are the place for the discussion of the gravest problems of medicine; they serve also to point out the great landmarks of the future. Three years ago, on the eve of the London Congress, the doctrine of micro-organisms, the ætiological cause of transmissible maladies, was still the subject of sharp criticisms. Certain refractory minds continued to uphold the idea that "disease is in us, from us, by us."

It was expected that the decided supporters of the theory of the spontaneity of diseases would make a bold stand in London; but no opposition was made to the doctrine of "exteriority," or external causes, the first cause of contagious diseases, and those questions were not discussed at all.

It was there seen, once again, that when all is ready for the final triumph of truth, the united conscience of a great assembly feels it instinctively and recognises it.

All clear-sighted minds had already foreseen that the theory of the spontaneity of diseases received its death-blow on the day when it became possible reasonably to consider the spontaneous generation of microscopic organisms as a myth, and when, on the other hand, the life-activity of those same beings was shown to be the main cause of organic decomposition and of all fermentation.

From the London Congress, also, dates the recognition of another very hopeful progress; we refer to the attenuation of different viruses, to the production of varying degrees of virulence for each virus, and their preservation by suitable methods of cultivation; to the practical application, finally, of those new facts in animal medicine.

New microbic prophylactic viruses have been added to those of fowl-cholera and of splenic fever. The animals saved from death by contagious diseases are now counted by hundreds of thousands, and the sharp opposition which those scientific novelties met with at the

beginning was soon swept away by the rapidity of their onward progress.

Will the circle of practical applications of those new notions be limited in future to the prophylaxis of animal distempers? We must never think little of a new discovery, nor despair of its fecundity; but more than that, in the present instance, it may be asserted that the question is already solved in principle. Thus, splenic fever is common to animals and man, and we make bold to declare that, were it necessary to do so, nothing could be easier than to render man also proof against that affection. The process which is employed for animals might, almost without a change, be applied to him also. It would simply become advisable to act with an amount of prudence which the value of the life of an ox or a sheep does not call for. Thus, we should use three or four vaccine-viruses instead of two, of progressive intensity of virulence, and choose the first ones so weak that the patient should never be exposed to the slightest morbid complication, however susceptible to the disease he might be by his constitution.

The difficulty, then, in the case of human diseases, does not lie in the application of the new method of prophylaxis, but rather in the knowledge of the physiological properties of their viruses. All our experiments must tend to discover the proper degree of attenuation for each virus. But experimentation, if allowable on animals, is criminal on man. Such is the principal cause of the complication of researches bearing on diseases exclusively human. Let us keep in mind, nevertheless, that the studies of which we are speaking were born yesterday only, that they have already yielded valuable results, and that new ones may be fairly expected when we shall have gone deeper into the knowledge of animal maladies, and of those in particular which affect animals in common with man.

The desire to penetrate farther forward in that double study led me to choose rabies as the subject of my researches, in spite of the darkness in which it was veiled.

The study of rabies was begun in my laboratory four years ago, and pursued since then without other interruption than what was inherent to the nature of the researches themselves, which present certain unfavourable conditions. The incubation of the disease is always protracted, the space disposed of is never sufficient, and it thus becomes impossible at a given moment to multiply the experiments as one would like. Notwithstanding those material obstacles, lessened by the interest

taken by the French Government in all questions of great scientific interest, we now no longer count the experiments which we have made, my fellow workers and myself. I shall limit myself to-day to an exposition of our latest acquisitions.

The name alone of a disease, and of rabies above all others, at once suggests to the mind the notion of a remedy.

But it will, in the majority of cases, be labour lost to aim in the first instance at discovering a mode of cure. It is, in a manner, leaving all progress to chance. Far better to endeavour to acquaint oneself, first of all, with the nature, the cause, and the evolution of the disease, with a glimmering hope, perhaps, of finally arriving at its prophylaxis.

To this last method we are indebted for the result that rabies is no longer to-day to be considered as an insoluble riddle.

We have found that the virus of rabies develops itself invariably in the nervous system, brain, and spinal cord, in the nerves, and in the salivary glands; but it is not present at the same moment in every one of those parts. It may, for example, develop itself at the lower extremity of the spinal cord, and only after a time reach the brain. It may be met with at one or at several points of the encephalon whilst being absent at certain other points of the same region.

If an animal is killed whilst in the power of rabies, it may require a pretty long search to discover the presence here or there in the nervous system, or in the glands, of the virus of rabies. We have been fortunate enough to ascertain that in all cases, when death has been allowed to supervene naturally, the swelled-out portion, or bulb, of the medulla oblongata nearest to the brain, and uniting the spinal cord with it, is always rabid. When an animal has died of rabies (and the disease always ends in death), rabid matter can with certainty be obained from its bulb, capable of reproducing the disease in other animals when inoculated into them, after trephining, in the arachnoid space of the cerebral meninges.

Any street dog whatsoever, inoculated in the manner described with portions of the bulb of an animal which has died of rabies, will certainly develop the same disease. We have thus inoculated several hundreds of dogs brought without any choice from the pound. Never once was the inoculation a failure. Similarly also, with uniform success, several hundred guinea-pigs, and rabbits more numerous still.

Those two great results, the constant presence of the virus in the bulb at the time of death, and the certainty of the reproduction of the

disease by inoculaion into the arachnoid space, stand out like experimental axioms, and their importance is paramount. Thanks to the precision of their application, and to the well-nigh daily repetition of those two criteria of our experiments, we have been able to move forward steadily and surely in that arduous study. But, however solid those experimental bases, they were, nevertheless, incapable in themselves of giving us the faintest notion as to some method of vaccination against rabies. In the present state of science the discovery of a method of vaccination against some virulent malady presupposes:

1. That we have to deal with a virus capable of assuming diverse intensities, of which the weaker ones can be put to vaccinal or protective uses.

2. That we are in possession of a method enabling us to reproduce those diverse degrees of virulence at will.

At the present time, however, science is acquainted with one sort of rabies only—viz., dog rabies.

Rabies, whether in dog, man, horse, ox, wolf, fox, etc., comes originally from the bite of a mad dog. It is never spontaneous, neither in the dog nor in any other animal. There are none seriously authenticated among the alleged cases of so-called spontaneous rabies, and I add that it is idle to argue that the first case of rabies of all must have been spontaneous. Such an argument does not solve the difficulty, and wantonly calls into question the as yet inscrutable problem of the origin of life. It would be quite as well, against the assertion that an oak tree always proceeded from another oak tree, to argue that the first of all oak trees that ever grew must have been produced spontaneously. Science, which knows itself, is well aware that it would be useless for her to discuss about the origin of things; she is aware that, for the present at any rate, that origin is placed beyond the ken of her investigations.

In fine, then, the first question to be solved on our way towards the prophylaxis of rabies is that of knowing whether the virus of that malady is susceptible of taking on varying intensities, after the manner of the virus of fowl-cholera or of splenic fever.

But in what way shall we ascertain the possible existence of varying intensities in the virus of rabies? By what standard shall we measure the strength of a virus which either fails completely or kills? Shall we have recourse to the visible symptoms of rabies? But those symptoms are extremely variable, and depend essentially on the particular point of the encephalon or of the spinal cord where the virus has in the

first instance fixed and developed itself. The most caressing rabies, for such do exist, may, when inoculated into another animal of the same species, give rise to furious rabies of the intensest type.

Might we then perhaps make use of the duration of incubation as a means of estimating the intensity of our virus? But what can be more changeful than the incubative period? Suppose a mad dog to bite several sound dogs: one of them will take rabies in one month or six weeks, another after two or three months or more. Nothing, too, more changeful than the length of incubation according to the different modes of inoculation. Thus, other circumstances the same, after bites or hypodermic inoculation rabies occasionally develops itself, and at other times aborts completely; but inoculations on the brain are never sterile, and give the disease after a relatively short incubation.

It is possible, nevertheless, to gauge with sufficient accuracy the degree of intensity of our virus by means of the time of incubation, on condition that we make use exclusively of the intra-cranial mode of inoculation; and secondly, that we do away with one of the great disturbing influences inherent to the results of inoculation made by bites, under the skin or in the veins, by injecting the right proportion of material.

The duration of incubation, as a matter of fact, may depend largely on the quantity of efficient virus—that is to say, on the quantity of virus which reaches the nervous system without diminution or modification. Although the quantity of virus capable of giving rabies may be, so to speak, infinitely small, as seen in the common fact of the disease developing itself after rabid bites which, as a rule, introduce into the system a barely appreciable weight of virus, it is easy to double the length of incubation by simply changing the proportion of those very small quantities of inoculated matter. I may quote the following examples:—

On May 10, 1882, we injected into the popliteal vein of a dog ten drops of a liquid prepared by crushing a portion of the bulb of a dog, which had died of ordinary canine madness, in three or four times its volume of sterilised broth.

Into a second dog we injected $\frac{1}{100}$th of that quantity, into a third $\frac{1}{200}$th. Rabies showed itself in the first dog on the eighteenth day after the injection, on the thirty-fifth day in the second dog, whilst the third one did not take the disease at all, which means that, for the last animal, with the particular mode of inoculation employed, the quantity of virus injected was not sufficient to give rabies. And yet that

dog, like all dogs, was susceptible of taking the disease, for it actually took it twenty-two days after a second inoculation, performed on September 3, 1882.

I now take another example bearing on rabbits, and by a different mode of inoculation. This time, after trephining, the bulb of a rabbit which had died of rabies after inoculation of an extremely powerful virus is triturated and mixed with two or three times its volume of sterilised broth. The mixture is allowed to stand a little, and then two drops of the supernatant liquid are injected after trephining into a first rabbit, into a second rabbit one-fourth of that quantity, and in succession into other rabbits, $\frac{1}{16}$th, $\frac{1}{64}$th, $\frac{1}{128}$th, and $\frac{1}{152}$nd of that same quantity. All those rabbits died of rabies, the incubation having been eight days, nine and ten days for the third and fourth, twelve and sixteen days for the last ones.

Those variations in the length of incubation were not the result of any weakening or diminution of the intrinsic virulence of the virus brought on possibly by its dilution, for the incubation of eight days was at once recovered when the nervous matter of all those rabbits was inoculated into new animals.

Those examples show that, whenever rabies follows upon bites or hypodermic inoculations, the differences in respect of length of incubation must be chiefly ascribed to the variations, at times within considerable limits, of the ever-undeterminate proportions of the inoculated viruses which reach the central nervous system.

If, therefore, we desire to make use of the length of incubation as a measure of the intensity of the virulence, it will be indispensable to have recourse to inoculation on the surface of the brain, after trephining, a process the action of which is absolutely certain, coupled with the use of a larger quantity of virus than what is strictly sufficient to give rise to rabies. By those means the irregularities in the length of incubation for the same virus tend to disappear completely, because we always have the maximum effect which that virus can produce; that maximum coincides with a minimum length of incubation.

We have thus, finally, become possessed of a method enabling us to investigate the possible existence of different degrees of virulence, and to compare them with one another. The whole secret of the method, I repeat, consists in inoculating on the brain, after trephining, a quantity of virus which, although small in itself, is still greater than what is simply necessary to reproduce rabies. We thus disengage the incu-

bation from all disturbing influences and render its duration dependent exclusively on the activity of the particular virus used, that activity being in each case estimated by the minimum incubation determined by it.

This method was applied in the first instance to the study of canine madness, and in particular to the question of knowing whether dog-madness was always one and the same, with perhaps the slight variations which might be due to the differences of race in diverse dogs.

We accordingly got hold of a number of dogs affected with ordinary street rabies, at all times of the year, at all seasons of the same year or of different years, and belonging to the most dissimilar canine races. In each case the bulbar portion of the medulla oblongata was taken out from the recently dead animal, triturated and suspended in two or three times its volume of sterilised liquid, making use all along of every precaution to keep our materials pure, and two drops of this liquid injected after trephining into one or two rabbits. The inoculation is made with a Pravaz syringe, the needle of which, slightly curved at its extremity, is inserted through the dura-mater into the arachnoid space. The results were as follows: all the rabbits, from whatever sort of dog inoculated, showed a period of incubation which ranged between twelve and fifteen days, without almost a single exception. Never did they show an incubation of eleven, ten, nine, or eight days, never an incubation of several weeks or of several months.

Dog-rabies, the ordinary rabies, the only known rabies, is thus sensibly one in its virulence, and its modifications, which are very limited, appear to depend solely on the varying aptitude for rabies of the different known races. But we are going now to witness a deep change in the virulence of dog-rabies.

Let us take one, any one, of our numerous rabbits, inoculated with the virus of an ordinary mad dog, and, after it has died, extract its bulb, prepare it just as described, and inject two drops of the bulb-emulsion into the arachnoid space of a second rabbit, whose bulb will in turn and in time be injected into a third rabbit, the bulb of which again will serve for a fourth rabbit, and so on.

There will be evidence, even from the first few passages, of a marked tendency towards a lessening of the period of incubation in the succeeding rabbits. Just one example:

Towards the end of the year 1882 fifteen cows and one bull died of rabies on a farm situated in the neighbourhood of the town of Melun.

They had been bitten on October 2 by the farm dog, which had become mad. The head of one of the cows, which had died on November 15, was sent to my laboratory by M. Rossignol, a veterinary surgeon in Melun. A number of experiments were made on dogs and rabbits, and showed that the following parts, the only encephalic (or those pertaining to the brain) ones tested, were rabid: the bulb, the cerebellum, the frontal lobe, the sphenoidal lobe. The rabbits trephined and inoculated with those different parts showed the first symptoms of rabies on the seventeenth and eighteenth days after inoculation. With the bulb of one of those rabbits two more were inoculated, of which one took rabies on the fifteenth day, the other on the twenty-third day.

We may notice, once for all, that when rabies is transferred from one animal to another of a different species, the period of incubation is always very irregular at first in the individuals of the second species if the virus had not yet become fixed in its maximum virulence for the first species. We have just seen an example of that phenomenon, since one of the rabbits had an incubation of fifteen days, the other of twenty-three days, both having received the same virus and all other circumstances remaining apparently the same for them.

The bulb of the first one of those last rabbits which died was injected into two more rabbits, still after trephining. One of them took rabies on the tenth day, the other on the fourteenth day. The bulb of the first one that died was again injected into a couple of new rabbits, which developed the disease in ten days and twelve days respectively. A fifth time two new animals were inoculated from the first one that died, and they both took the disease on the eleventh day after inoculation; similarly, a sixth passage was made, and gave an incubation of eleven days, twelve days for the seventh passage, ten and eleven for the eighth, ten days for the ninth and tenth passages, nine days for the eleventh, eight and nine days for the twelfth, and so on, with differences of twenty-four hours at the most, until we got to the twenty-first passage, when rabies declared itself in eight days, and subsequently to that always in eight days up to the fiftieth passage, which was only effected a few days ago. That long experimental series which is still going on was begun on November 15, 1882, and will be kept up for the purpose of preserving in our rabies virus that maximum virulence which it has come to now for some considerable time, as it is easy to calculate.

Allow me to call your attention to the ease and safety of the opera-

tions for trephining and then inoculating the virus. Throughout the last twenty months we have been able without a single interruption in the course of the series to carry the one initial virus through a succession of rabbits which were all trephined and inoculated every twelfth day or so.

Guinea-pigs reach more rapidly the maximum virulence of which they are susceptible. The period of incubation is in them also variable and irregular at the beginning of the series of successive passages, but it soon enough fixes itself at a minimum of five days. The maximum virulence in guinea-pigs is reached after seven or eight passages only. It is worth noting that the number of passages required before reaching the maximum virulence, both in guinea-pigs and in rabbits, varies with the origin of the first virus with which the series is begun.

If now this rabies with maximum virulence be transferred again into the dog from guinea-pig or rabbit, there is produced a dog-virus which in point of virulence goes far beyond that of ordinary canine madness.

But, a natural query—of what use can be that discovery as to the existence and artificial production of diverse varieties of rabies, every one of them more violent and more rapidly fatal than the habitual madness of the dog? The man of science is thankful for the smallest find he can make in the field of pure science, but the many, terrified at the very name of hydrophobia, claim something more than mere scientific curiosities. How much more interesting it would be to become acquainted with a set of rabies viruses which should, on the contrary, be possessed of attenuated degrees of virulence! Then, indeed, might there be some hope of creating a number of vaccinal rabies viruses such as we have done for the virus of fowl-cholera, of the microbe of saliva, of the red evil of swine (swine-plague), and even of acute septicæmia. Unfortunately, however, the methods which had served for those different viruses showed themselves to be either inapplicable or inefficient in the case of rabies. It therefore became necessary to find out new and independent methods, such, for example, as the cultivation *in vitro* of the mortal rabies virus.

Jenner was the first to introduce into current science the opinion that the virus which he called the grease of the horse, and which we call now more exactly horse-pox, probably softened its virulence, so to speak, in passing through the cow and before it could be transferred to man without danger. It was therefore natural to think of a possible

diminution of the virulence of rabies by a number of passages through the organisms of some animal or other, and the experiment was worth trying. A large number of attempts were made, but the majority of the animal species experimented on exalted the virulence after the manner of rabbits and guinea-pigs; fortunately, however, it was not so with monkey.

On December 6, 1883, a monkey was trephined and inoculated with the bulb of a dog, which had itself been similarly inoculated from a child who had died of rabies. The monkey took rabies eleven days later, and when dead served for inoculation into a second monkey, which also took the disease on the eleventh day. A third monkey, similarly inoculated from the second one, showed the first symptoms on the twenty-third day, etc. The bulb of each one of the monkeys was inoculated, after trephining, into two rabbits each time. The rabbits inoculated from the first monkey developed rabies between thirteen and sixteen days, those from the second monkey between fourteen and twenty days, those from the third monkey between twenty-six and thirty days, those from the fourth monkey both of them after the twenty-eighth day, those from the fifth monkey after twenty-seven days, those from the sixth monkey after thirty days.

It cannot be doubted after that, that successive passages through monkeys, and from the several monkeys to rabbits, do diminish the virulence of the virus for the latter animals; they diminish it for dogs also. The dog inoculated with the bulb of the fifth monkey gave an incubation of no less than fifty-eight days, although it had been inoculated in the arachnoid space.

The experiments were renewed with fresh sets of monkeys and led to similar results. We were therefore actually in possession of a method by means of which we could attenuate the virulence of rabies. Successive inoculations from monkey to monkey elaborate viruses which, when transferred to rabbits, reproduce rabies in them, but with a progressively lengthening period of incubation. Nevertheless, if one of those rabbits be taken as the first for inoculations through a series of rabbits, the rabies thus cultivated obeys the law which we have seen before, and has its virulence increased at each passage.

The practical application of those facts gives us a method for the vaccination of dogs against rabies. As a starting point, make use of one of the rabbits inoculated from a monkey sufficiently removed from the first animal of the monkey series for the inoculation—hypodermic

or intra-venous—of that rabbit's bulb not to be mortal for a new rabbit. The next vaccinal inoculations are made with the bulbs of rabbits derived by successive passages from that first rabbit.

In the course of our experiments we made use, as a rule, for inoculation, of the virus of rabbits which had died after an incubation of four weeks, repeating three or four times each the vaccinal inoculations made with the bulbs of rabbits derived in succession from one another and from the first one of the series, itself coming directly from the monkey. I abstain from giving more details, because certain experiments which are actually going on allow me to expect that the process will be greatly simplified.

You must be feeling, gentlemen, that there is a great blank in my communication; I do not speak of the micro-organism of rabies. We have not got it. The process for isolating it is still imperfect, and the difficulties of its cultivation outside the bodies of animals have not yet been got rid of, even by the use, as pabulum, of fresh nervous matter. The methods which we employed in our study of rabies ought all the more perhaps, on that account, to fix attention. Long still will the art of preventing diseases have to grapple with virulent maladies the micro-organic germs of which will escape our investigations. It is, therefore, a capital scientific fact that we should be able, after all, to discover the vaccination process for a virulent disease without yet having at our disposal its special virus and whilst yet ignorant of how to isolate or to cultivate its microbe.

As soon as the method for the vaccination of dogs was firmly established, and we had in our possession a large number of dogs which had been rendered refractory to rabies, I had the idea of submitting to a competent committee those of the facts which appeared destined in future to serve as a basis for the vaccination of dogs against rabies. That course was suggested to me in prevision of the later practical application of the method, by the recollection of the opposition with which Jenner's discovery met at its beginning.

I spoke of my project to M. Fallières, the Minister of Public Instruction, who was pleased to approve of it and gave commission to the following gentlemen to control the facts which I had summarily communicated to the Academy of Sciences in its sitting of May 19 last: Messrs. Béclard, Paul Bert, Bouley, Aimeraud, Villemin, Vulpian. M. Bouley was appointed president, Dr. Villemin secretary, and the commission at once set to work. I have the pleasure of informing you

that it has just sent in a first report to the Minister. I was acquainted with it here, and the following are in a few words the facts related in that first report on rabies. I had given to the commission nineteen vaccinated dogs in succession—that is to say, dogs which had been rendered refractory by preventive inoculations. Thirteen only of them had after their vaccination been already submitted to the test-inoculation on the brain.

The nineteen dogs were, for the sake of comparison, divided into sets along with nineteen more control dogs brought from the pound without any sort of selection. To begin with, two refractory dogs and two control dogs were on June 1 trephined and inoculated under the dura-mater, on the surface of the brain, with the bulb of a dog affected with ordinary street rabies.

On June 3 another refractory dog and another control dog were bitten by a furious street mad dog.

The same furious mad dog was on June 4 made to bite still another refractory and another control dog. On June 6 the furious dog which had been utilised on June 3 and 4 died. The bulb was taken out and inoculated, after trephining, into three refractory dogs and three control dogs. On June 10 another street mad dog, having been secured, was, by the commission, made to bite one refractory and one control dog. On June 16 the commission have two new dogs, a refractory one and a control one, bitten by one of the control dogs of June 1, which had been seized with rabies on June 14 in consequence of the inoculation after trephining which it had received on June 1.

On June 19 the commission got three refractory and three control dogs inoculated before their own eyes in the popliteal vein with the bulb of an ordinary street mad dog. On June 20 they have inoculated in their presence, and still in a vein, ten dogs altogether, six of them refractory and four just brought from the pound.

On June 28, the Commission hearing that M. Paul Simon, a veterinary surgeon, had a furious biting mad dog, have four of their dogs, two refractory and two control dogs, taken to his place and bitten by the mad dog.

The Rabies Commission have, therefore, experimented on thirty-eight dogs altogether—namely, nineteen refractory dogs and nineteen control dogs susceptible of taking the disease. Those of the dogs which have not died in consequence of the operations themselves are still under observation, and will long continue to be. The commission, reporting

up to the present moment on their observations as to the state of the animals tried and tested by them, find that out of the nineteen control dogs six were bitten, of which six three have taken rabies. Seven received intra-venous inoculations, of which five have died of rabies. Five were trephined and inoculated on the brain; the five have died of rabies.

On the other hand, not one of the nineteen vaccinated dogs has taken rabies.

In the course of the experiments, on July 13, one of the refractory dogs died in consequence of a black diarrhœa which had begun in the first days of July. In order to ascertain whether rabies had anything to do with it as the cause of death, its bulb was at once inoculated, after trephining, into three rabbits and one guinea-pig. All four animals are still to-day in perfect health, a certain proof that the dog died of some common malady, and not of rabies.

The second report of the Commission will be concerned with the experiments made as to the refractoriness to rabies of twenty dogs to be vaccinated by the Commission themselves.

(*M. Pasteur then announced that he had just received that same morning the first report addressed to M. Fallieres by the Official Commission on Rabies. It states that twenty-three refractory dogs were bitten by ordinary mad dogs, and that not one of them had taken rabies. On the other hand, within two months after the bites, 66 per cent. of the normal dogs similarly bitten had already taken the disease.*)

November 1, 1886.—*New Communication on Rabies.*—On October 26, 1885, I acquainted the Academy with a method of prophylaxis of rabies after bites. Numerous applications on dogs had justified me in trying it on man. As early as March 1, 350 persons bitten by dogs undoubtedly mad, and several more by dogs simply suspected of rabies, had already been treated at my laboratory by Dr. Grancher. And in consideration of the happy results obtained it appeared to me that it had become necessary to found an establishment for anti-rabic vaccinations.

To-day, October 31, 1886, 2,490 persons have received the preventive inoculations in Paris alone. The treatment was in the first instance uniform for the great majority of the patients, notwithstanding the different conditions presented by them as to age, sex, the number of bites received, their seat, their depth, and the time which had elapsed

since the occurrence of the accident. It lasted ten days, the patient receiving every day an injection prepared from the spinal marrow of a rabbit, beginning with that of fourteen days' and ending with that of five days' desiccation.

Those 2,490 cases are subdivided according to nationality in the following manner:

Russia	191
Italy	165
Spain	107
England	80
Belgium	57
Austria	52
Portugal	25
Roumania	22
United States	18
Holland	14
Greece	10
Germany	9
Turkey	7
Brazil	3
India	2
Switzerland	2
France and Algeria	1,726

The number of French persons has been considerable, amounting to 1,726, and it will be enough to confine ourselves to the category formed by them as a basis for discussing the degree of efficacy of the method.

Out of the total 1,726 cases treated, the treatment has failed ten times—namely, in the following cases:

The children: Lagut, Peytel, Clédière, Moulis, Astier, Videau.

The woman: Leduc, seventy years old.

The men: Marius Bouvier (thirty years), Clergot (thirty), and Norbert Magnevon (eighteen).

I leave out of count two other persons, Louise Pelletier and Moermann, whose deaths must be attributed to their tardy arrival at the laboratory, Louise Pelletier thirty-six days, and Moermann forty-three days after they had been bitten.

We have therefore ten deaths for 1,726 cases, or 1 in 170; such are, for France and Algeria, the results of the first year's application of the method.

Those statistics, taken as a whole, demonstrate the efficacy of the treatment, as proved further by the relatively large number of deaths which occurred amongst bitten persons who had not been vaccinated.

PROSPERINE

By Rossetti, 1828-1882.

DANTE GABRIEL ROSSETTI was born in London, England, May 12, 1828. His mother was English and his father was an Italian professor and poet, who was made professor of the King's College, London, in 1831 and afterwards commentator on Dante.

After attending a private school for nine months (from the autumn of 1835-1836), he was sent to King's College School, where he remained until 1842. From a child he had shown a propensity for drawing and it was therefore assumed that his career should be an artistic one. And although he left school young he knew Latin, French, and Italian, and later he had some German lessons. He also had some Greek. On leaving school he went to Cary's Art Academy, and in 1846 obtained admission to the Royal Academy Antique School. In 1849 he exhibited his picture, The Girlhood of Mary, Virgin, and in the same year took an active part in forming the Pre-Raphaelite brotherhood, the members of which believed that artists should confront Nature herself, imitating no longer the imitations of her—even though the imitations be the splendid works of those great masters which had hitherto been the inspiration of modern art. This made him very unpopular for a time. In 1851 he wrote the memorial poem, Sister Helen. He wrote many poems before 1862 and had them arranged for a volume under the title of Dante at Verona, and other poems. His wife died in this year from an overdose of laudanum taken for neuralgia, and Rossetti buried his manuscripts with her. Six years later he was persuaded to consent to their disinterment. They were published in 1870 and gave him a reputation second to no other contemporary English poet after Tennyson and Browning. Much of the remainder of Rossetti's life may be summed up in a phrase, "chloral and its consequences." He first took this drug by the advice of a friend to relieve neuralgia and insomnia. Rossetti obtained equal celebrity as a poet and as a painter. It has been disputed in which class he stands higher.

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PSYCHOLOGY

Descriptions of the mind or soul begin with Plato and Aristotle. Locke may be called the father of psychology of modern times. The Germans tried to add exactness to psychology by an experimental method. Lotze in 1852, Fechner in 1860 and Wundt in 1863 all did much to bring this experimental point of view to a practical working basis. A great many facts have been discovered by laboratory methods and such investigations are still being pursued.

In 1861 Broca discovered that the brains of persons suffering one kind of aphasia showed a lesion in a certain spot.

About 1870 Hitzig showed that special movements could be excited in a dog by electrification of various parts of the brain. By this method and by comparing the injuries in the brains of persons suffering from nervous disorders, Ferrier and Munk, six or seven years later, established local centers for the senses of sight, hearing, touch, and smell. All of this introduced an entirely new conception of the relation of brain and mind. Briefly put, the facts are these: destroy a center in the brain and you destroy the corresponding sense or motion; destroy the path between two centers and the relation between corresponding ideas is destroyed; thus a patient may see his coat and not know what it is for. Moreover, not only does a lesion destroy the power of sight, for example, but *takes away the memory of things seen.* The question of localization is one of the most interesting in psychology, and has already made possible surgical operations on the brain for diseases which previous ages did not connect with the brain at all.

DAVID FERRIER

David Ferrier was born at Aberdeen, Scotland, in 1843. In 1863 he graduated from the University of Aberdeen with the highest honors and in the same year won the Ferguson scholarship in classics and philosophy, open for competition to graduates of the four Scotch Universities. In 1854 he entered the University of Heidelburg, where he carried on his psychological studies and began to study anatomy, physiology, and chemistry; in 1865 he began the study of medicine at the University of Edinburg, where he graduated in 1868 after having won several medals. He remained at the university as assistant to the Professor of the Practice of Physic until 1869, and the year following, assisted a practitioner at Bury, St. Edmunds, where he managed to still prosecute his researches on the comparative anatomy and histology of the brain. In 1871 he was appointed Demonstrator of Physiology in King's College, and in 1872 Professor of Forensic Medicine in the same institution, succeeding Dr. Grey, whom he had assisted in preparing the fourth and fifth editions of his *Principles of Forensic Medicine*. He retained this position until 1889. He also became junior physician to the West London Hospital in 1872, assistant physician to King's College Hospital in 1874, and full physician in 1880. He was assistant physician to the Hospital for Paralysis and Epilepsy, Regent's Park, from 1877 to 1880, when he was appointed physician to the National Hospital for the Paralyzed and Epileptic. He has published numerous memoirs. Dr. Ferrier's chief scientific work has been connected with the brain. He proved that the senses and powers of movement were closely connected with definite centers in the brain; that the destruction of these centers would destroy the corresponding mental power and not only would the sense itself be destroyed, but the memory of past sensations corresponding to the injured center. He was one of the founders and is still editor of the journal *Brain*.

LOCALIZATION OF THE FUNCTIONS IN THE BRAIN

Hitherto we have considered the brain chiefly in its objective or physiological aspects, and the conclusion has been arrived at that the brain is a complex system of centres of motion and centres of sensation.

In their subjective aspect the functions of the brain are synonymous with mental operations, the consideration of which belongs to the science of psychology and the subjective method of investigation. No purely physiological investigation can explain the phenomena of consciousness. By throwing light, however, on the anatomical substrata of consciousness, physiological experiment may serve to elucidate some of the at present obscure relations between normal and abnormal conditions of the brain, and normal and abnormal psychical manifestations.

It is not the object of this work to attempt an analysis of mind or the laws of mental operations, but simply to discuss, in the light of the facts revealed by the experimental investigations recorded in the preceding chapters, some of those relations between the physiological and psychological functions of the brain which present themselves to the consideration of the physician and medical psychologist.

That the brain is the organ of the mind, and that mental operations are possible only in and through the brain, is now so thoroughly well established and recognized that we may without further question start from this as an ultimate fact.

But how it is that molecular changes in the brain cells coincide with modifications of consciousness; how, for instance, the vibrations of light falling on the retina excite the modification of consciousness termed a visual sensation, is a problem which cannot be solved. We may succeed in determining the exact nature of the molecular changes which occur in the brain cells when a sensation is experienced, but this will not bring us one whit nearer the explanation of the ultimate nature of that which constitutes the sensation. The one is objective and the other subjective, and neither can be expressed in terms of the other. We cannot say that they are identical, or even that the one passes into the other; but only, as Laycock expresses it, that the two are correlated, or, with Bain, that the physical changes and the psychical modifications are the objective and subjective sides of a "double-faced unity."

"We have every reason for believing that there is, in company with

all our mental processes, *an unbroken material succession.* From the ingress of a sensation, to the outgoing responses in action, the mental succession is not for an instant dissevered from a physical succession. A new prospect bursts upon the view; there is a mental result of sensation, emotion, thought, terminating in outward displays of speech or gesture. Parallel to this mental series is the physical series of facts, the successive agitation of the physical organs. . . . While we go the round of the mental circle of sensation, emotion and thought, there is an unbroken physical circle of effects. It would be incompatible with everything we know of cerebral action, to suppose that the physical chain ends abruptly in a physical void, occupied by an immaterial substance; which immaterial substance, after working alone, imparts its results to the other edge of the physical break, and determines the active response—two shores of the material, with an intervening ocean of the immaterial. There is, in fact, no rupture of nervous continuity. The only tenable supposition is, that mental and physical proceed together, as undivided twins. When, therefore, we speak of a mental cause, a mental agency, we have always *a two-sided cause;* the effect produced is not the effect of mind alone, but of mind in company with body." (Bain, "Mind and Body," 1873, p. 131.)

In accordance with this position it must follow from the experimental data that mental operations in the last analysis must be merely the subjective side of sensory and motor substrata. This view has been repeatedly and clearly enunciated by Hughlings-Jackson, with whose physiological and psychological deductions from clinical and pathological data I frequently find myself in complete accordance. ("Clinical and Physiological Researches on the Nervous System." Reprints from "Lancet," 1873.)

The physiological activity of the brain is not, however, altogether co-extensive with its psychological functions. The brain as an organ of motion and sensation, or presentative consciousness, is a single organ composed of two halves; the brain as an organ of ideation, or re-presentative consciousness, is a dual organ, each hemisphere complete in itself. When one hemisphere is removed or destroyed by disease, motion and sensation are abolished unilaterally, but mental operations are still capable of being carried on in their completeness through the agency of the one hemisphere. The individual who is paralysed as to sensation and motion by disease of the opposite side of the brain (say the right), is not paralysed mentally, for he can still feel and will and think, and intelligently comprehend with the one hemisphere. If these functions are not carried on with the same vigour as before, they at least do not appear to suffer in respect of completeness.

In order that impressions made on the individual organs of sense

shall excite the subjective modification called a sensation, it is necessary that they reach and induce certain molecular changes in the cells of their respective cortical centres.

If the angular gyrus (gyri) is destroyed or functionally inactive, impressions made on the retina and optical apparatus cause the same physical modifications as usual, but do not affect consciousness. The changes produced have no subjective side.

The optical apparatus without the angular gyrus may be compared to the camera without the sensitised plate. The rays of light are focussed as usual, but produce no chemical action, and leave no trace when the object is withdrawn, or the light from it shut off. The angular gyrus is like the sensitive plate. The cells undergo certain molecular modifications which coincide with certain subjective changes constituting the consciousness of the impression or special visual sensation. And as the sensitive plate records, in certain chemical decompositions, the form of the object presented to the camera, so the angular gyrus records in cell modifications the visual characters of the object looked at. We may push the analogy still further. Just as the chemical decomposition effected by the rays of light may be fixed and form a permanent image of the object capable of being looked at, so the cell modifications which coincided with the presentation of the object to the eye, remain permanently, constituting the organic memory of the object itself. When the same cell modifications are again excited, the object is re-presented or rises up in idea. It is not meant by this analogy that the objects are photographed in the angular gyrus, as objects are photographed on the plate, but merely that permanent cell modifications are induced, which are the physiological representatives of the optical characters of the object presented to the eye. The optical characters are purely light vibrations, and few objects are known by these alone. The object appeals to other senses, and perhaps to movements, and the idea of the object as a whole is the revival of the cell modifications in each of the centres concerned in the act of cognition. For what is true of the angular gyrus or sight centre is true, *mutatis mutandis,* of the other sensory centres. Each is the organic basis of consciousness of its own special sensory impressions, and each is the organic basis of the memory of such impressions in the form of certain cell modifications, the reinduction of which is the re-presentation or revival in idea of the individual sensory characters of the object. The organic cohesion of these elements by association renders it possible for the re-excitation of the one set of characters to recall the whole.

The sensory centres, therefore, are to be regarded not merely as the organs of consciousness of immediate sensory impressions, but as the organic register of special sensory experiences. This organic memory is the physical basis of Retentiveness, and the property of re-excitability is the organic basis of Recollection and Ideation. We have thus a physiological foundation of the law arrived at on other grounds by Bain, *viz.* that "the renewed feeling occupies the very same parts, and in the same manner as the original feeling." According to Spencer, the renewal of the feeling is the *faint* revivification of the same processes which are *strongly* excited by presentation of the object. The molecular thrill, if we may so term it, of present sensation extending from the peripherical organ of sense, is in the ideal sensation revived, but, as a rule, not so powerfully as to extend to the periphery; though, in rare instances, the central revivification may be so intense as actually to re-induce the peripherical impression. This occurs in certain morbid states such as are described under the name of "fixed ideas," or in sensory hallucinations from diseased conditions of the brain, as in epilepsy and insanity.

The organic memory of sensory impressions is the fundamental basis of knowledge. If the sense impressions were evanescent, or endured only so long as the object was present, the range of conscious intelligent action would be limited to the present, and we should have no real knowledge. Knowledge implies the consciousness of agreement or difference. We can only be said to *know* when we recognise identity, or difference between past and present conscious modifications. We know that a certain colour is green by recognising a similarity or identity between the present and a certain past colour sensation, or a difference between this and some other colour in the spectrum. If we had no organic memory of the past capable of re-excitation to serve as the basis of comparison, we should be unable to recognise either agreement or difference. We might be conscious from moment to moment, but there would be no continuation in time, and knowledge would be impossible. The foundation of the consciousness of agreement is the re-excitation by the present of the same molecular processes which coincided with a past impression; and of difference, a transition from one physical modification to another. The sensory centres, therefore, besides being the organs of sensation or consciousness of immediate impressions, contain, in the persistence and revivability of the coincident physical modifications, the materials and possibilities of simple and complex cognitions, in so far as these are dependent on sensory experience alone.

The destruction of the sight centre, therefore, not only makes the individual blind presentatively, but blind re-presentatively or ideally, and *all memories into which visual characters enter in part or whole become mangled and imperfect, or are utterly rooted out of consciousness.* The destruction of the eye renders the individual blind only presentatively, but his visual memory and visual ideation remain unaffected. And it would be extremely interesting to ascertain whether, in an individual born blind, the sight centre presents any peculiarities either as regards the forms of the cells, or their processes or otherwise, differing from those of the normal brain. If such were detectable, we should come near arriving at the characters of the physical basis of an idea.

In the remarkable and, in a physio-psychological sense, highly instructive condition termed aphasia, many of the principles above laid down are strikingly exemplified.

The subject of aphasia is deprived of the faculty of articulate speech, and also very generally of the faculty of expressing his thoughts in writing, while he continues intelligently to comprehend the meaning of words spoken to him, or, it may be, to appreciate the meaning of written language. An aphasic individual knows perfectly well, as exhibited by his gestures, if a thing is called by its right name or not, but he cannot utter the word himself, or write it when it is suggested to him. In his attempts, only an automatic or interjectional expression or some unintelligible jargon escapes his lips, or unmeaning scrawls are set down on paper as writing.

This affection is usually, at first at least, associated with a greater or less degree of right hemiplegia, but the motor affection of the right side, chiefly of the right arm, is often slight and transient, or may be wanting from the first, the only indication of motor paralysis being a paretic or weak condition of the oral muscles of the right side.

The inability to speak is not due to paralysis of the muscles of articulation, for these are set in action and employed for purposes of mastication and deglutition by the aphasic individual.

The cause of this affection was shown by Broca—and his observations have been confirmed by thousands of other cases—to be associated with disease in the region of the posterior extremity of the third left frontal convolution, where it abuts on the fissure of Sylvius, and overlaps the island of Reil, a region which I have shown corresponds with the situation of the motor centres of articulation in the monkey.

One of the most common causes of the affection is softening of this

region, consequent on sudden stoppage of the circulation by embolic plugging of the arterial channels which convey its blood supply, by which the functional activity of the part is temporarily or permanently suspended.

Owing to the proximity and common vascular supply of the motor centres of the hand and facial muscles, it is easy to see how they also become implicated in the lesion of the centres of articulation, and why, therefore, dextral and facial motor paralysis should so commonly occur along with aphasia. This may be taken as further evidence in proof of the fact that lesions of the cortical motor centres cause motor paralysis on the opposite side.

The escape of the articulatory muscles from paralysis in unilateral lesion of the centres of articulation is accounted for by the bilateral influence of each centre which has been experimentally demonstrated.

The loss of speech actually or in idea from destruction of the centres of articulation is not more difficult of explanation on the principles laid down in this chapter, than the loss of sight presentatively or representatively from destruction of the angular gyri. That which constitutes the apparent difficulty is the explanation of speechlessness without motor paralysis from unilateral lesion of the centres of articulation in the left hemisphere.

This difficulty is explicable on the principles laid down in reference to motor acquisitions in general. As the right side of the body is more especially concerned in volitional motor acts, so the education is principally in the motor centres of the left hemisphere, and these centres are more especially the organic basis of motor acquisitions. The left articulatory centres, as has been argued by more than one observer, preponderate over the right in the initiation of motor acts of articulation. They are, therefore, more especially the organic basis of the memory of articulations and of their revival in idea. The destruction of the left articulatory centres removes the motor limb of the cohesions which have been formed by long education between the centres of hearing and sight, and between the centres of ideation in general.

Sounds actual or revived fail to excite corresponding articulations actually or in idea. The individual is speechless, the motor part of the sensori-motor cohesion, sound-articulation, being broken. The sight of written symbols also fails to reproduce the equivalent articulatory action, actually or in idea. The individual is speechless, because the motor element of the sensori-motor cohesion, sight-articulation, is broken.

Ideally revived sights, sounds, touches, tastes, smells fail to call up

the symbolic articulations, hence the individual cannot express his ideas in language, and in so far as language or internal speech is necessary to complex trains of thought, in that proportion is thought impaired. Thought, however, may be carried on without language, but it is thought in particulars, and is as cumbrous and limited as mathematical calculations without algebraical symbols. Thought, as has been observed by Bain, is in a great measure carried on by internal speech, *i. e.,* through the ideal or faint re-excitation of the articulatory processes which are symbolic of ideas. This is shown by the unconsciously executed movements of the lips and tongue which all persons exhibit more or less, and some so obviously that the unconscious processes rise almost to the point of whispering. So also the blind deaf-mute Laura Bridgman, whose language was symbolic movements of the fingers, during thought or when dreaming, unconsciously executed the same movements as she was accustomed to make in the actual exercise of her manual speech.

And just as ideas tend to excite their symbolic representations in articulation or in manual movements, so does the actual or ideal revival of the articulatory or manual movements tend by association to call up the other limbs of the cohesions, whether simple sights, sounds, tastes, smells, or their combinations. The importance of this connection between the articulating centres and the centres of ideation in general, will be shown more fully in reference to the voluntary revival of ideas and control of ideation.

We have seen that a person aphasic from destruction of his speech centre (as we may for shortness call the articulatory motor centres of the left hemisphere) still remains capable of appreciating the meaning of words uttered in his hearing. In this respect he does not (and there is no reason why he should) differ from a normal individual. His centres of sight, hearing, etc., being unimpaired, he is as capable as before of sight, auditory, tactile, gustatory and olfactory ideation. The difference consists in the fact that in the aphasic individual the word spoken, though it calls up the idea or meaning, cannot call up the word itself actually or in idea, owing to the centres of word execution and word ideation being destroyed. The appreciation of the meaning of spoken words is readily accounted for by the fact that in the process of education an association is formed directly between certain sounds and certain objects of sense, simultaneously with, if not antecedent to, the formation of the cohesive association between these sounds and certain acts of articulation. The cohesion or association between sound and meaning remains unimpaired in aphasia; it is the cohesion between

sound and articulation which is broken, by removal of the motor factor of the organic nexus.

The association between visible symbols and things signified is, however, secondary to the associations formed between sounds and things signified, and between sounds and articulations, for speech precedes the art of writing. In the first instance, when an individual is learning to read, visible symbols are translated into articulations and revived sounds before they call up the things signified. This translation occurs in all at first, and continues apparent in those persons not much accustomed to reading, for they only understand by articulating in a more or less suppressed manner all the while. Just as an individual in learning a foreign language is at first obliged to translate the words into his vernacular before he reaches the meaning, but comes by familiarity and practice to associate the new words with their meaning directly without the aid of the vernacular, and even to think in the new language, so it is possible that by long experience in reading, a direct association may be established between visible symbols and things signified, without the mediation of articulation. In such a case a person who has his speech centre disorganised will still be able to comprehend the meaning of written language. A person, on the other hand, who has not established the direct association between visible symbols and things signified, and is still obliged to translate through articulation, will, by destruction of his speech centre, fail to comprehend written language, though he may still understand spoken language.

In learning to write a new association has to be grafted on to the association already formed between sounds and articulations. The new cohesion is between sounds and certain symbolic manual movements guided by sight, which symbolic tracings are the equivalents of certain acts of articulation. In the first instance this association between sounds, or sounds and things signified, and manual movements, takes place through the mediation of the centres of articulation, for the sounds or ideas are first reproduced actually or internally by articulations before their equivalence in written symbols is established and recognised.

By education, and by the familiarity engendered of long practice in expressing ideas by written symbols, a direct association becomes established between sounds and ideas, and symbolic manual movements, without the intermediation of articulation; and in proportion as the translation through articulation is dispensed with, in that proportion will an individual continue able to write who is aphasic from disease of his speech centre.

In the great majority of cases of aphasia, met with in hospitals, the direct association between sounds and ideas and manual equivalents of articulations has not been established, except for very simple and constantly repeated acts of writing such as signing one's name: and hence, as the intervention of articulation is still necessary before ideas can be expressed in writing, destruction of the speech centre causes not merely aphasia, but also *agraphia*.

Examples of all these different conditions are to be met with in aphasia. Some can neither speak nor write; some can write but cannot speak; some can write their names but cannot write anything else; all can comprehend spoken language; many can comprehend written language; others not at all, or very imperfectly. Between the normal condition of the speech centre and its total destruction, many intermediate abnormal conditions occur, which exemplify themselves as partial aphasia, and partial disorders of speech. In some cases there seems to be such a perturbation of the centres, that though the individual is not aphasic in the sense of being speechless, yet the associations between certain articulations and certain ideas are so disturbed that in attempts to speak only an incoherent jumble of words comes forth. This is a condition of ataxia rather than aphasia in the proper sense of the term.

The speech centre is, as has been stated, in the great majority of instances situated in the left hemisphere. But there is no reason, beyond education and heredity, why this should necessarily be so. It is quite conceivable that the articulating centres of the right hemisphere should be educated in a similar manner. A person who has lost the use of his right hand may by education and practice acquire with his left all the cunning of the right. In such a case the manual motor centres of the right hemisphere become the centres of motor acquisitions similar to those of the left. As regards the articulating centres, the rule seems to be that they are educated, and become the organic seat of volitional acquisitions on the same side as the manual centres. Hence, as most people are right-handed, the education of the centres of volitional movements takes place in the left hemisphere. This is borne out in a striking manner by the occurrence of cases of aphasia with left hemiplegia in left-handed people. Several cases of this kind have now been put on record. (*Vide* Thèse Mongié, Paris, 1866; quoted by Lépine, "La Localisation dans les Maladies Cérébrales," Paris, 1875. Russell, "Med. Times and Gazette," July 11, Oct. 24, 1874. Case (unpublished) communicated to me by my friend Dr. Lauder Brunton, of St. Bartholomew's Hospital.)

These cases more than counterbalance any exception to the rule that the articulating centres are educated volitionally on the same side as the manual motor centres. The rule need not be regarded as absolute, and we may admit exceptions without invalidating a single conclusion respecting the pathology of aphasia as above laid down.

Though the left articulatory centre is the one commonly and specially educated in speech, it is quite conceivable that a person who has become aphasic by reason of total and permanent destruction of the left speech centre, may reacquire the faculty of speech by education of the right articulatory centres. To a certain extent they have undergone education along with those of the left through associated action, registering automatically, as Hughlings-Jackson puts it, the volitional acts of the left. This automatic may be educated into volitional power, though at the age at which aphasia usually occurs, there is less capacity and plasticity in the nerve centres for forming new cohesions and associations. The rapid recovery which so frequently occurs in cases of aphasia, especially of the kind due to embolic plugging of the nutrient arteries of the left centres, is not so much to be regarded as an indication of the education of the right centres, but rather of the re-establishment of the circulation and nutrition in parts only temporarily rendered functionless.

But there are other cases which would seem to show that recovery of speech may take place after a lesion which has caused complete and permanent destruction of the left speech centre. A case which seems to me to be of this nature has been reported by Drs. Batty, Tuke and Fraser ("Journal of Mental Science," April, 1872), who, however, have adduced it as an instance opposed to the localisation of a speech centre, which in one sense, *i. e.,* as against absolute unilateral localisation, it certainly is. The case in essentials is that of a female patient who was rendered unconscious by the occurrence of cerebral hemorrhage. On her recovery she was found totally speechless, and she remained so for an indefinite period. In process of time, however, the faculty of speech was restored in great measure, though never quite perfectly. "During the whole period of her residence two peculiarities in her speech were observed—a thickness of articulation resembling that of general paralysis, and a hesitancy when about to name anything, the latter increasing very much some months previous to her death.

"The thickness seemed apparently due to slight immobility of the upper lip when speaking, but there was no paralysis when the lip was

voluntarily compressed against its fellow. The inaction of the upper lip was observed by all.

"The hesitancy was most marked when she came to a noun, the hiatus varying in duration according to the uncommonness of the word. Latterly, she could not recall even the commonest terms, and periphrases or gestures were used to indicate her meaning. She was always relieved and pleased if the words were given her, when she invariably repeated them. For example, she would say, 'Give me a glass of ——.' If asked if it was 'water?' she said, 'No.' 'Wine?' 'No.' 'Whisky?' 'Yes, whisky.' *Never did she hesitate to articulate the word when she heard it.*"

Death occurred fifteen years after the seizure, and it was found *post mortem* that there was total destruction and loss of substance in the cortical region in the left hemisphere corresponding with the position of the centres of articulation. This seems to me one of the clearest cases of re-acquisition of the faculty of speech by education of the articulating centres of the right side. That speech was lost in the first instance is in harmony with the usual effect of lesion of the left speech centre. Education of the right side had not become quite perfect even after fifteen years, and that peculiar hesitancy, and the fact, which the authors themselves have specially noted in italics, that speech often required the aid of suggestion, is in accordance with the less volitional and greater automatic power of the right hemisphere. Aphasia being essentially due to the destruction, temporary or permanent, of the centres of excitation and organic registration of acts of articulation, is a significant proof of the fact that there is no break between the physiological and psychological functions of the brain, and that the objective and subjective are not separated from each other by an unbridgeable gulf.

We have now traced the development of the volitional control of the movements, and the mode in which the memory of volitional acts becomes organised in the motor centres. The conclusion reached is that the volitional control of the movements becomes established when an organic cohesion is welded between a consciously discriminated feeling and a definite and differentiated motor act. The volitional control of the individual movements having once been established the work of education advances, and the conditions of volition become more and more complex. The volition of the untutored and inexperienced infant is of a more or less impulsive character, its action being conditioned mainly by impressions or ideas of the moment. Associations have not yet been formed between the pleasurable and painful remote consequences of actions. *Experientia docet.* A child which has acquired the differentiated control of its hands is impelled to touch and handle whatever

strongly attracts its sight. The sight of a bright flame stimulates a desire to handle it. This is followed by severe bodily pain, and an association is formed between touching a certain brilliant object and severe suffering. The vivid memory of pain experienced on a former occasion, is sufficient to counteract the impulse to touch when the child is again placed in similar circumstances. Here we have a simple case of the conflict of motives, and the inhibition or neutralisation of one motive by another and stronger. Action, if it results at all, is conditioned by the stronger. Similarly, a hungry dog is impelled by the sight of food to seize and eat. Should the present gratification bring with it as a consequence the severe pain of a whipping, when certain articles of food have been seized, an association is formed between eating certain food and severe bodily pain; so that on a future occasion the memory of pain arises simultaneously with the desire to gratify hunger, and, in proportion to the vividness of the memory of pain, the impulse of appetite is neutralised and counteracted. The dog is said to have learnt to curb its appetite.

As experience increases, the associations between acts and consequences increase in complexity. Both by personal experience, as well as by the observed experience and testimony of others, associations are established between actions and their remote consequences as pleasures or pains, and it is found that present gratification may bring a greater and future pain, and actions causing present pain may bring a greater pleasure. As the great law of life is *vivere convenientur naturae*—to secure pleasure and avoid pain in the highest and most general sense, and not for the moment only (a law which cannot be transgressed with impunity)—actions are conditioned no longer, as in the infant or untutored animal, by present desires or feelings alone, but by present desires modified by the ideally revived feelings of plasure or pain near and remote, which experience has associated with definite actions. The motive to action is thus the resultant of a complex system of forces; the more complex, the wider the experience, and the more numerous the associations formed between actions and their consequences, near and remote. Actions so conditioned are regarded as mature or deliberate, in contradistinction to impulsive volitions, but the difference is not in kind, but only in degree of complexity; for in the end, actions conditioned by the resultant of a complex system of associations are of essentially the same character as those conditioned by the simple stimulus of a present feeling or desire, where no other associations have as yet been formed capable of modifying it.

But what is normal in the infant or untutored animal, may be positive insanity on the part of the educated adult. If in him actions are conditioned merely by present feelings or desires, irrespective of, or in spite of, the associations formed by experience between such acts and their consequences as pains, there is a reversion to the infantile type of volition; the only difference being, that in the one case no opposing associations have as yet been formed, while in the other, though formed, they prove of no avail. An individual who so acts, acts irrationally; and if in anyone, notwithstanding the opposing influence of past associations, a present feeling or desire reaches such a pitch of intensity as to overbalance these associations, the individual is said to act in spite of himself, or, metaphorically, against his will. Such tendencies occur more or less in all, but they are exemplified more especially in certain forms of insanity, in which the individual becomes the victim of some morbid desire, and is impelled irresistibly, and to his horror, to commit some act fraught with dreadful consequences.

The tendency of feelings or desires to expend themselves in action leads to the consideration of another faculty which plays an important part in the regulation and control of ideation and action.

The primordial elements of the volitional acts of the infant, and also of the adult, are capable of being reduced in ultimate physiological analysis to reaction between the centres of sensation and those of motion.

But besides the power to act in response to feelings or desires, there is also the power to inhibit or restrain action, notwithstanding the tendency of feelings or desires to manifest themselves in active motor outbursts.

Inhibition of action is either direct or indirect.

As an example of indirect inhibition, we may take the inhibition of reflex action, which is caused by a simultaneous stronger sensory stimulus. This is paralleled in volitional action by the inhibition or neutralisation of one motive by another and stronger.

As an example of direct inhibition, we may take the inhibitory action of the vagus upon the heart. This is due to an influence of the vagus on the cardiac motor ganglia by which their activity is restrained. "The heart contains within itself numerous ganglia, which keep up its rhythmical contractions even for some time after it has been removed from the body. The terminal branches of the vagus nerve in the heart are connected in some way with these ganglia, and whenever it is irritated the ganglia cease to act on the muscular substance, and the heart stands completely still in a relaxed condition. The branches of the

vagus which have this action resemble motor nerves in their conveying an irritation applied to them towards the periphery, and not towards the centre, and also in their origin, for although they run in the vagus they are really derived from the spinal accessory nerve, and only join the vagus near its origin. The other fibres of the spinal accessory go to muscles, and when they are excited they set the muscles in action, but those going to the heart do not end in the muscular fibres, but in the ganglia, and they produce rest instead of motion, relaxation instead of contraction." (Lauder-Brunton, "On Inhibition, Peripheral and Central," "West Riding Lunatic Asylum Medical Reports," vol. iv., p. 181.) The centres of direct inhibition are thus truly motor in character, but their action is expended in the motor centres proper.

As an illustration of volitional inhibition we may take the power, accompanied with the feeling of effort, to rein in and inhibit the tendency of powerful feelings to exhibit themselves in action. The battle between inhibition and the tendency to active motor outburst, is indicated by the tension into which the muscles are thrown, and yet kept reined in, so that under a comparatively calm exterior there may be a raging fire, threatening to burst all bonds.

The inhibitory centres are not equally developed or educated in all, nor are they equally developed in the same individual in respect to particular tendencies to action. But this faculty of inhibition appears to me to be a fundamental element in the attentive concentration of consciousness and control of ideation.

It has been properly remarked that we have no direct volitional control over the centres of ideation. Ideas once excited centrally or from peripherical impressions tend to excite each other in a purely reflex manner, as Laycock and Carpenter have pointed out. Left to themselves ideas excite ideas along the lines of association of contiguity and similarity—coherently in the waking state, when all the centres and senses are functionally active; incoherently in dreams and delirium, where the various centres are functioning irregularly.

But we have the power of concentrating attention on one idea, or class of ideas, and their immediate associates, to the exclusion of all others, a power differently developed in different individuals. We can thus modify and control the current of ideation, and we can also, to a certain extent, voluntarily call up and retain in consciousness particular ideas and particular associations of ideas.

On what physiological basis this psychological faculty rests is an extremely difficult question, and is one scarcely capable of experimental

determination. The following considerations are therefore more properly speculations than deductions from experimental data.

Both the voluntary excitation of ideas and the concentration of consciousness by which the current of ideation is controlled, seem to be essentially dependent on the motor centres. The fact that attention involves the activity of the motor powers has been clearly enunciated by Bain and Wundt.

Bain ("The Emotions and the Will," 3rd ed. 1875) remarks as follows:—"It is not obvious at first sight that the retention of an idea in the mind is operated by voluntary muscles. Which movements are operating when I am cogitating a circle, or recollecting St. Paul's? There can be no answer given to this, unless on the assumption that the mental or revived image occupies the same place in the brain and other parts of the system as the original sensation did, a position supported by a number of reasons adduced in my former volume ("Contiguity," §10). Now there being a muscular element in our sensations, especially of the higher senses—touch, hearing, sight—this element must somehow or other have a place in the after remembrance of the idea.

"The ideal circle is a restoring of those currents that would prompt the sweep of the eye round an ideal circle; the difference lies in the last stage, or in stopping short of the actual movement performed by the organ" (p. 370).

In these sentences, and particularly the last, Bain seems to me to have clearly indicated the elements of attention, which I conceive to be a combination of the activity of the motor, and of the inhibitory-motor centres.

In calling up an idea, or when engaged in the attentive consideration of some idea or ideas, we are in reality throwing into action, but in an inhibited or suppressed manner, the movements with which the sensory factors of ideation are associated in organic cohesion.

We think of form by initiating and then inhibiting the movements of the eyes or hands through which and by which ideas of form have been gained and persist. And just as sensory impressions or sensory ideas tend by association to call up ideal or actual movements, so conversely, the excitation of movements tends to call up by association the various sensory factors which combine with these particular movements to form complex ideas. In the case of ideas, the motor element of which is not apparent, the method of excitation can be referred to the articulatory movements with which as symbols ideas are associated. This is, in fact, the most usual method of recalling ideas in general. We recall an object in idea by pronouncing the name in a suppressed manner. We think, therefore, and direct the current of thought in a great measure by means of internal speech.

This is essentially the case with respect to the recalling of abstract ideas as contradistinguished from concrete and particular.

The abstract qualities and relations of objects exist only by reason of words, and we think of the concrete or particular instances out of which the general or abstract have been formed, by making the symbolic movements of articulation with which these ideas cohere.

An aphasic individual is incapable of abstract ideation or trains of thought. He thinks only in particulars, and his thoughts are conditioned mainly by present impressions on his organs of sense, arousing ideas according to the usual laws of association.

The recall of an idea being thus apparently dependent on excitation of the motor element of its composition, the power of fixing the attention and concentrating consciousness depends, further, on inhibition of the movement.

During the time we are engaged in attentive ideation we suppress actual movements, but keep up in a state of greater or less tension the centres of the movement or movements with which the various sensory factors of ideation cohere.

By checking the tendency to outward diffusion in actual motion, we thereby increase the internal diffusion, and concentrate consciousness. For the degree of consciousness is inversely proportional to the amount of external diffusion in action. In the deepest attention, every movement which would diminish internal diffusion is likewise inhibited. Hence, in deep thought, even automatic actions are inhibited, and a man who becomes deep in thought while he walks, may be observed to stand still.

The excitation of the motor centres, inhibited from external diffusion, expends its force internally along the lines of organic cohesion, and the various factors which have become organically coherent with any particular movement rise into consciousness. This inhibited excitation of a motor centre may be compared to tugging at a plant with branching roots. The tension causes a vibratile thrill to the remotest radicle. So the tension of the motor centre keeps in a state of conscious thrill the ideational centres organically coherent therewith. The centres of inhibition would therefore form the chief factor in the concentration of consciousness and the control of ideation. They have, however, no self-determining power of activity, but are called into action by the same stimuli which tend to excite actual movement. The centres of inhibition undergo education along with the centres of actual motion

during the growth of volition. The education of the centres of inhibition introduces the element of deliberation into volition, for action at the instigation of present feelings is suspended until the various associations which have clustered round any individual act have arisen in consciousness. The resultant of the various associations, the revival of which is conditioned by the present feeling and the concentration of consciousness which it instigates, is the motive which ultimately determines the action.

In proportion to the development and degree of education of the centres of inhibition do acts of volition lose their impulsive character, and acquire the aspect of deliberation. Present impulses or feelings, instead of at once exciting action, as in the infant, stimulate the centres of inhibition simultaneously, and suspend action until, under the influence of attention, the associations engendered by past experience between actions and their pleasurable or painful consequences, near and remote, have arisen in consciousness. If the centres of inhibition, and thereby the faculty of attention, are weak, or present impulses unusually strong, volition is impulsive rather than deliberate.

The centres of inhibition being thus the essential factor of attention, constitute the organic basis of all the higher intellectual faculties. And in proportion to their development we should expect a corresponding intellectual power.

"A great profusion of remembered images, ideas, or notions, avails little for practical ends without the power of arrest or selection, which in its origin is purely voluntary. We may have the luxuriousness of a reverie or a dream, but not the compliance with a plan of operations, or with rules of composition." (Bain, p. 371.)

In proportion to the development of the faculty of attention are the intellectual and reflective powers manifested. This is in accordance with the anatomical development of the frontal lobes of the brain, and we have various experimental and pathological data for localising in these the centres of inhibition, the physiological substrata of this psychological faculty.

It has already been shown that electrical irritation of the anterofrontal lobes causes no motor manifestations, a fact which, though a negative one, is consistent with the view that, though not actually motor, they are inhibitory-motor, and expend their energy in inducing internal changes in the centres of actual motor execution.

Centres of direct inhibition and nerves of inhibition are, as we have seen, all centrifugal, or motor, in character, and it has also been shown that the frontal regions are directly connected with the centrifugal, or motor, tracts of the peduncular expansion or corona radiata.

The removal of the frontal lobes causes no motor paralysis, or other evident physiological effects, but causes a form of mental degradation, which may be reduced in ultimate analysis to loss of the faculty of attention.

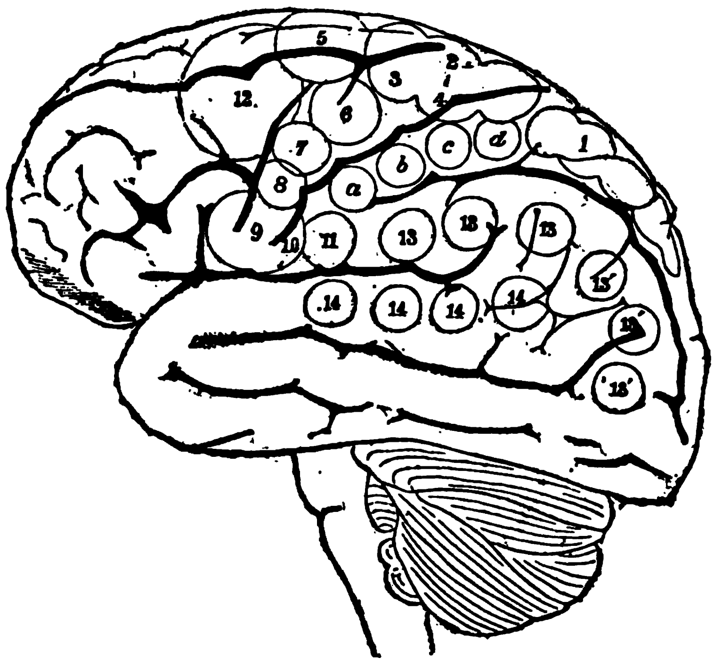
The powers of attention and concentration of thought are, further, small and imperfect in idiots with defective development of the frontal lobes, and disease of the frontal lobes is more especially characteristic of dementia or general mental degradation. The frontal regions which correspond to the non-excitable regions of the brain of the monkey are small or rudimentary in the lower animals, and their intelligence and powers of reflective thought correspond.

The development of the frontal lobes is greatest in man with the highest intellectual powers, and taking one man with another, the greatest intellectual power is characteristic of the one with the greatest frontal development.

The phrenologists have, I think, good grounds for localising the reflective faculties in the frontal regions of the brain, and there is nothing inherently improbable in the view that frontal development in special regions may be indicative of the power of concentration of thought and intellectual capacity in special directions.

In this chapter I have contented myself with indicating very briefly some of the more important psychological principles which seem to me fairly deducible from experimental investigation into the anatomical and physiological substrata of mind, principles which in many respects coincide with those expounded by Bain and Herbert Spencer.

Many other important points in cerebral physiology still remain to be considered, such as the relation of the encephalic centres to nutritive or trophic processes; the conditions of the normal activity of the brain: the physiological conditions of consciousness, etc.; but as these questions require discussion in the light more of the phenomena of disease in man, than of experiments on the lower animals, I propose to reserve these and similar topics for another treatise, specially devoted to the consideration of diseases of the brain.



(1), placed on the postero-parietal lobule, indicates the position of the centres for movements of the opposite leg and foot such as are concerned in locomotion.

(2), (3), (4), placed together on the convolutions bounding the upper extremity of the fissure of Rolando, include centres for various complex movements of the arms and legs, such as are concerned in climbing, swimming, etc.

(5), situated at the posterior extremity of the superior frontal convolution, at its junction with the ascending frontal, is the centre for the extension forwards of the arm and hand, as in putting forth the hand to touch something in front.

(6), situated on the ascending frontal, just behind the upper end of the posterior extremity of the middle frontal convolution, is the centre for the movements of the hand and forearm in which the biceps is particularly engaged, *viz.*, supination of the hand and flexion of the forearm.

(7) and (8), centres for the elevators and depressors of the angle of the mouth respectively.

(9) and (10), included together in one, mark the centre for the movements of the lips and tongue, as in articulation. This is the region, disease of which causes aphasia, and is generally known as Broca's convolution.

(11), the centre of the platysma, retraction of the angle of the mouth.

(12), a centre for lateral movements of the head and eyes, with elevation of the eyelids and dilation of pupil.

(*a*), (*b*), (*c*), (*d*), placed on the ascending parietal convolution, indicate the centres of movement of the hand and wrist.

Circles (13) and (13′) placed on the supra-marginal lobule and angular gyrus, indicate the centre of vision.

Circles (14) placed on the superior temporo-sphenoidal convolution, indicate the situation of the centre of hearing.

The centre of smell is situated in the subiculum cornu Ammonis (inner surface of brain).

In close proximity, but not exactly defined as to limits, is the centre of taste.

The centre of touch is situated in the hippocampal region. [But feeling centres seem also to be located in the same regions as the corresponding motor centres.—Ed.]

SIR WILLIAM CROOKES

Sir William Crookes was born in London in 1832. Since 1851 he has given himself to original research in chemistry. In 1859 he founded the "Chemical News" and in 1864 became editor also of the "Quarterly Journal of Science." He is both a practical and theoretical chemist,—an authority on sewage, beet sugar, dyeing, calico printing; the inventor of the Crookes' tube which led to Röntgen's discoveries; and a theorizer on the ultimate composition of the atom. He is a believer in telepathy, and his deep insight into the laws of radiant energy demands a careful consideration of the hypothesis he explains below.

TELEPATHY

The task I am called upon to perform to-day is to my thinking by no means a merely formal or easy matter. It fills me with deep concern to give an address, with such authority as a president's chair confers, upon a science which, though still in a purely nascent stage, seems to me at least as important as any other science whatever. Psychical science, as we here try to pursue it, is the embryo of something which in time may dominate the whole world of thought. This possibility—nay, probability—does not make it the easier to me now. Embryonic devel-

opment is apt to be both rapid and interesting; yet the prudent man shrinks from dogmatising on the egg until he has seen the chicken.

Nevertheless, I desire, if I can, to say a helpful word. And I ask myself what kind of helpful word. Is there any connection between my old-standing interest in psychical problems and such original work as I may have been able to do in other branches of science?

I think there is such a connection—that the most helpful quality which has aided me in psychical problems and has made me lucky in physical discoveries (sometimes of rather unexpected kinds) has simply been my knowledge—my vital knowledge, if I may so term it—of my own ignorance.

Most students of nature sooner or later pass through a process of writing off a large percentage of their supposed capital of knowledge as a merely illusory asset. As we trace more accurately certain familiar sequences of phenomena we begin to realize how closely these sequences, or laws, as we call them, are hemmed round by still other laws of which we can form no notion. With myself this writing off of illusory assets has gone rather far and the cobweb of supposed knowledge has been pinched (as some one has phrased) into a particularly small pill.

Telepathy, the transmission of thought and images directly from one mind to another without the agency of the recognized organs of sense, is a conception new and strange to science. To judge from the comparative slowness with which the accumulated evidence of our society penetrates the scientific world, it is, I think, a conception even scientifically repulsive to many minds. We have supplied striking experimental evidence; but few have been found to repeat our experiments. We have offered good evidence in the observation of spontaneous cases, as apparitions at the moment of death and the like, but this evidence has failed to impress the scientific world in the same way as evidence less careful and less coherent has often done before. Our evidence is not confronted and refuted; it is shirked and evaded as though there were some great a priori improbability which absolved the world of science from considering it. I at least see no a priori improbability whatever. Our alleged facts might be true in all kinds of ways without contradicting any truth already known. I will dwell now on only one possible line of explanation, not that I see any way of elucidating all the new phenomena I regard as genuine, but because it seems probable I may shed a light on some of those phenomena.

All the phenomena of the universe are presumably in some way

continuous; and certain facts, plucked as it were from the very heart of nature, are likely to be of use in our gradual discovery of facts which lie deeper still.

Let us, then, consider the vibrations we trace, not only in solid bodies, but in the air, and in a still more remarkable manner in the ether.

These vibrations differ in their velocity and in their frequency. That they exist, extending from one vibration to two thousand millions of millions vibrations per second, we have good evidence. That they subserve the purpose of conveying impressions from outside sources of whatever kind to living organisms may be fully recognized.

As a starting point I will take a pendulum beating seconds in air. If I keep on doubling I will get a series of steps as follows:

Starting point.	The seconds pendulum.	
Step 1....	2	vibrations per second.
2....	4	
3....	8	
4....	16	
5....	32	Sound begins to human ear.
6....	64	
7....	128	
8....	256	
9....	512	
10....	1024	
15....	32768	Sound ends to human ear and electrical waves begin.
20....	1,048576	
25....	33,554432	
30....	1073,741825	
35....	34359,738368	Electrical waves end.
40....	1,099511,627776	
45....	35,184372,088832	Light waves begin for human eye.
50....	1125,899906,842624	Light waves end for human eye.
55....	36028,707018,963968	
56....	72057,594037,927936	
57....	144115,188075,855872	
58....	288220,376151,711744	X-rays begin?
59....	576440,752303,423488	
60....	1,152881,504606,846976	
61....	2,305763,009213,693952	
62....	4,611526,018427,387904	
63....	9,223052,036854,775808	

At the fifth step from unity, at 32 vibrations per second, we reach the region where atmospheric vibration reveals itself to us as sound. Here we have the lowest musical note. In the next ten steps the vibrations per second rise from 32 to 32,768, and here, to the average human ear, the region of sound ends. But certain more highly endowed ani-

mals probably hear sounds too acute for our organs; that is, sounds which vibrate at a higher rate.

We next enter a region in which the vibrations rise rapidly, and the vibrating medium is no longer the gross atmosphere, but a highly attenuated medium, "a diviner air," called the ether. From the sixteenth to the thirty-fifth step the vibrations rise from 32,768 to 34359,738368 a second, such vibrations appearing to our means of observation as electrical rays.

We next reach a region extending from the thirty-fifth to the forty-fifth step, including from 34359,738368 to 35,184372,088832 vibrations per second. This region may be considered as unknown, because we are as yet ignorant what are the functions of vibrations of the rates just mentioned. But that they have some function it is fair to suppose.

Now we approach the region of light, the steps extending from the forty-fifth to between the fiftieth and the fifty-first, and the vibrations extending from 35,184372,088832 per second (heat rays) to 1875,000000,000000 per second, the highest recorded rays of the spectrum. The actual sensation of light, and therefore the vibrations which transmit visible signs, being comprised between the narrow limits of about 450,000000,000000 (red light) and 750,000000,000000 (violet light)—less than one step.

Leaving the region of visible light we arrive at what is, for our existing senses and our means of research, another unknown region, the functions of which we are beginning to suspect. It is not unlikely that the X-rays of Professor Röntgen will be found to lie between the fifty-eighth and the sixty-first step, having vibrations extending from 288220,576151,711744 to 2,305763,009213, 693952 per second, or even higher.

In this series it will be seen there are two great gaps, or unknown regions, concerning which we must own our entire ignorance as to the part they play in the economy of creation. Further, whether any vibrations exist having a greater number per second than those classes mentioned we do not presume to decide.

But is it premature to ask in what way are vibrations connected with thought or its transmission? We might speculate that the increasing rapidity or frequency of the vibrations would accompany a rise in the importance of the functions of such vibrations. That high frequency deprives the rays of many attributes that might seem incompatible with "brain waves" is undoubted. Thus, rays about the sixty-

second step are so minute as to cease to be refracted, reflected, or polarized; they pass through many so-called opaque bodies, and research begins to show that the most rapid are just those which pass most easily through dense substances. It does not require much stretch of the scientific imagination to conceive that at the sixty-second or sixty-third step the trammels from which rays at the sixty-first step were struggling to free themselves have ceased to influence rays having so enormous a rate of vibration as 9,223052,036854,775808 per second, and that these rays pierce the densest medium with scarcely any diminution of intensity, and pass almost unrefracted and unreflected along their path with the velocity of light.

Ordinarily we communicate intelligence to each other by speech. I first call up in my own brain a picture of a scene I wish to describe, and then, by means of an orderly transmission of wave vibrations set in motion by my vocal chords through the material atmosphere, a corresponding picture is implanted in the brain of anyone whose ear is capable of receiving such vibrations. If the scene I wish to impress on the brain of the recipient is of a complicated character, or if the picture of it in my own brain is not definite, the transmission will be more or less imperfect; but if I wish to get my audience to picture to themselves some very simple object, such as a triangle or a circle, the transmission of ideas will be well-nigh perfect, and equally clear to the brains of both transmitter and recipient. Here we use the vibrations of the material molecules of the atmosphere to transmit intelligence from one brain to another.

In the newly discovered Röntgen rays we are introduced to an order of vibrations of extremest minuteness as compared with the most minute waves with which we have hitherto been acquainted, and of dimensions comparable with the distances between the centers of the atoms of which the material universe is built up; and there is no reason to suppose that we have here reached the limit of frequency. Waves of this character cease to have many of the properties associated with light waves. They are produced in the same ethereal medium, and are probably propagated with the same velocity as light, but here the similarity ends. They cannot be regularly reflected from polished surfaces; they have not been polarized; they are not refracted on passing from one medium to another of different density, and they penetrate considerable thicknesses of substances opaque to light with the same ease with which light passes through glass. It is also demonstrated that these rays, as generated in

the vacuum tube, are not homogeneous, but consist of bundles of different wave-lengths, analogous to what would be differences of color could we see them as light. Some pass easily through flesh, but are partially arrested by bone, while others pass with almost equal facility through bone and flesh.

It seems to me that in these rays we may have a possible mode of transmitting intelligence which, with a few reasonable postulates, may supply a key to much that is obscure in psychical research. Let it be assumed that these rays, or rays even of higher frequency, can pass into the brain and act on some nervous center there. Let it be conceived that the brain contains a center which uses these rays as the vocal chords use sound vibrations (both being under the command of intelligence), and sends them out, with the velocity of light, to impinge on the receiving ganglion of another brain. In this way some, at least, of the phenomena of telepathy, and the transmission of intelligence from one sensitive to another through long distances, seem to come into the domain of law and can be grasped. A sensitive may be one who possesses the telepathic transmitting or receiving ganglion in an advanced state of development, or who, by constant practice, is rendered more sensitive to these high-frequency waves. Experience seems to show that the receiving and the transmitting ganglions are not equally developed; one may be active, while the other, like the pineal eye in man, may be only vestigial. By such an hypothesis no physical laws are violated; neither is it necessary to invoke what is commonly called the supernatural.

To this hypothesis it may be objected that brain waves, like any other waves, must obey physical laws. Therefore, transmission of thought must be easier or more certain the nearer the agent and recipient are to each other, and should die out altogether before great distances are reached. Also it can be urged that if brain waves diffuse in all directions they should affect all sensitives within their radius of action, instead of impressing only one brain. The electric telegraph is not a parallel case, for there a material wire intervenes to conduct and guide the energy to its destination.

These are weighty objections, but not, I think, insurmountable. Far be it from me to say anything disrespectful of the law of inverse squares, but I have already endeavored to show we are dealing with conditions removed from our material and limited conceptions of space, matter, form. Is it inconceivable that intense thought concentrated toward a

sensitive with whom the thinker is in close sympathy may induce a telepathic chain of brain waves, along which the message of thought can go straight to its goal without loss of energy due to distance? And is it also inconceivable that our mundane ideas of space and distance may be superseded in these subtile regions of unsubstantial thought, where "near" and "far" may lose their usual meaning?

I repeat that this speculation is strictly provisional. I dare to suggest it. The time may come when it will be possible to submit it to experimental tests.

I am impelled to one further reflection, dealing with the conservation of energy. We say, with truth, that energy is transformed, but not destroyed, and that whenever we can trace the transformation we find it quantitatively exact. So far as our very rough exactness goes, this is true for inorganic matter and for mechanical forces. But it is only inferentially true for organized matter and for vital forces. We cannot express life in terms of heat or of motion. And thus it happens that just when the exact transformation of energy will be most interesting to watch, we cannot really tell whether any fresh energy has been introduced into the system or not. Let us consider this a little more closely.

It has, of course, always been realized by physicists, and has been especially pointed out by Dr. Croll, that there is a wide difference between the production of motion and the direction of it into a particular channel. The production of motion, molar or molecular, is governed by physical laws, which it is the business of the philosopher to find out and correlate. The law of the conservation of energy overrides all laws, and it is a pre-eminent canon of scientific belief that for every act done a corresponding expenditure of energy must be transformed. No work can be effected without using up a corresponding value in energy of another kind. But to us the other side of the problem is even of more importance. Granted the existence of a certain kind of molecular motion, what is it that determines its direction along one path rather than another? A weight falls to the earth through a distance of 3 feet. I lift it, and let it fall once more. In these movements of the weight a certain amount of energy is expended in its rise and the same amount is liberated in its fall. But instead of letting the weight fall free, suppose I harness it to a complicated system of wheels, and, instead of letting the weight fall in the fraction of a second, I distribute its fall over twenty-four hours. No more energy is expended in raising the weight,

and in its slow fall no more or less energy is developed than when it fell free; but I have made it do work of another kind. It now drives a clock, a telescope, or a philosophic instrument, and does what we call useful work. The clock runs down. I lift the weight by exerting the proper amount of energy, and in this action the law of conservation of energy is strictly obeyed. But now I have the choice of either letting the weight fall free in a fraction of a second, or, constrained by the wheel-work, in twenty-four hours. I can do which I like, and whichever way I decide, no more energy is developed in the fall of the weight. I strike a match; I can use it to light a cigarette or to set fire to a house. I write a telegram; it may be simply to say I shall be late for dinner, or it may produce fluctuations on the stock exchange that will ruin thousands. In these cases the actual force required in striking the match or in writing the telegram is governed by the law or conservation of energy; but the vastly more momentous part, which determines the words I use or the material I ignite, is beyond such a law. It is probable that no expenditure of energy need be used in the determination of direction one way more than another. Intelligence and free will here come into play, and these mystic forces are outside the law of conservation of energy as understood by physicists.

The whole universe, as we see it, is the result of molecular movement. Molecular movements strictly obey the law of conservation of energy, but what we call "law" is simply an expression of the direction along which a form of energy acts, not the form of energy itself. We may explain molecular and molar motions, and discover all the physical laws of motion, but we shall be as far as ever from a solution of the vastly more important question as to what form of will and intellect is behind the motions of molecules, guiding and constraining them in definite directions along predetermined paths. What is the determining cause in the background? What combination of will and intellect outside our physical laws guides the fortuitous concourse of atoms along ordered paths culminating in the material world in which we live?

In these last sentences I have intentionally used words of wide signification—have spoken of guidance along ordered paths. It is wisdom to be vague here, for we absolutely cannot say whether or when any diversion may be introduced into the existing system of earthly forces by an external power. We can no more be certain that this is not so than I can be certain, in an express train, that no signalman has pressed a handle to direct the train onto this or that line of rails. I may compute

exactly how much coal is used per mile, so as to be able to say at any minute how many miles we have traveled, but, unless I actually see the points, I cannot tell whether they are shifted before the train passes.

An omnipotent being could rule the course of this world in such a way that none of us should discover the hidden springs of action. He need not make the sun stand still upon Gibeon. He could do all that he wanted by the expenditure of infinitesimal diverting force upon ultramicroscopic modifications of the human germ.

In this address I have not attempted to add any item to the sound knowledge which I believe our society is gradually amassing. I shall be content if I have helped to clear away some of those scientific stumbling-blocks, if I may so call them, which tend to prevent many of our possible coadjutors from adventuring themselves on the new illimitable road.

I see no good reason why any man of scientific mind should shut his eyes to our work or deliberately stand aloof from it. Our proceedings are, of course, not exactly parallel to the proceedings of a society dealing with a long-established branch of science. In every form of research there must be a beginning. We own to much that is tentative, much that may turn out erroneous. But it is thus, and thus only, that each science in turn takes its stand. I venture to assert that both in actual careful record of new and important facts, and in suggestiveness, our society's work and publications will form no unworthy preface to a profounder science both of man, of nature, and of "worlds not realized" than this planet has yet known.

PHILOLOGY

Philology may be said to have made its first beginning as a science when Bopp (1791-1867) in 1816 showed the original identity of personal endings of verbs with personal pronouns, and of the endings of what are called in Gothic weak verbs with the verb *to do*. The second great step was Grimm's law of consonant permutation (1822), which showed that there are regular consonant changes and correspondences between the Teutonic and other so-called Aryan languages. The law and illustrations of it are given below. The law established an Aryan family of languages, and subsequent scholars have done much to trace out the primitive Aryan civilization through the study of the words that can be traced back to that prehistoric time. In 1877 Karl Verner showed that the apparent exceptions to Grimm's law depended on an original difference of accent. Verner's law is given below. This emphasized the fact that there is a cause for all changes in language, and that all are conformable to regular law. In pursuance of this idea, philologists have since traced the history of the vowels and found them as regular as the consonant mutations.

The histories of the Germanic and Romance languages have been written. The wonderful changes undergone by Latin words in being mouthed over by the Gauls at the time of the Roman occupation of France have been shown regular for each class. This forms the basis of modern French. The history of English is another great result of the science, and there are few words in English that cannot be shown to correspond on the one hand if native to German or classical cognates, or on the other if derived, traced back either directly or through French to their classsical originals.

It must be remembered that all this is the study of the ideas of the race as well as of words or forms, because the words carry in them the primitive conceptions of their originators. Comparative philology has lent a great interest to the study of Sanscrit and Persian, and our knowledge of the Indian and Persian classics, of Brahmanism, Buddhism, Zoroasterism, is all due to the advance in the science of language.

THE CONSONANTS

We will discuss the subject but briefly. The most noticeable correspondences of English and German, and of English and Latin and Greek, are those included under Grimm's Law and Verner's modification of it.

Grimm's Law may be most briefly stated as follows:

Take the following series of mutes:

Dentals	d	t	dh	d
Labials	b	p	bh	b
Palatals	g	k	gh	g
Velars	gw	qu	ghw	gw

Then, if a native English and a Latin or Greek word go back to the same original, where the Latin or Greek word has any letter of the above series, the native English word will have the one following.

This law is subject to some regular special modifications in the different languages. German has often shifted one step further than English and this has regularly taken place in the dental series. Teutonic t becoming German z or s. Teutonic p is usually German f. The following tables show the principal correspondences in the languages in which we are most interested:

Aryan	Greek	Latin	Gothic	A. S.	Eng.	O. H. G.	German
				D			
decm	déka	decem	taihun	ten	ten	zehan	zehn
duo	duo	duo	twai	twa	two	zwei nt.	zwei
dakru	dakru	lacrima	tagr	tear	tear	zahar	Zähre
		lingua	tuggo	tunge	tongue	zunga	Zunge
	domos	domus		tam	tame	zam	zahm
dnt, dont	odonta (acc.)	dentem (acc.)	tunthus	toth	tooth	zan(d)	Zahn
edo	dérein (flay)		getairan	teran	tear (vb.)	firzeran	zehran
	edo	edo	itan	etan	eat	ezzan	essen
pod, ped-	poda (acc.)	pedem	fotus	fot	foot	fuoz	Fuss
v(e)id	oida, idein	videre	wait	wat	wot	wizzan	wissen
sed-	hézomia	sedeo	sitan	sittan	sit	sizzen	sitzen
kard-	kardia	cordem	kairto	heorte	heart	herza	Herz
swad-	hadus	suavis	*swotus	swete	sweet	suozi	süss
sw(o)id-	hidros	sudor	*swaid	swat	sweat	sweiz	Schweiss
udra	hudra	unda	*utrs	otor	otter	ottar	Otter
				T			
teg,- tog-	tégos	tegere, toga	*thak	thaec	thatch	dah	Dach
tn,- ten-	teino	tenuis	thunnus	thynne	thin	dunni	dünn
treyes	treis	tres	thrija, threis*	hreo	three	dri	drei
tu	tu, su	tu		thu	thou	du	du
ten, ton-	tonos	tonare	*thunara	thunor	thunder	donor	Donner
esti	esti	est	ist	is	is	ist	ist

Aryan	Greek	Latin	Gothic	A. S.	Eng.	O. H. G.	German
str-	storénnumi	sterno	straujan	streowian	strew	strewen	Streu
sta-	histami	stare	standan	standan	stand	sten	stehen, Stand
pet-	pétomai	penna	*fithra	fether	feather	fedara	Feder
mrt-	brotos	mortem		morthor	murder	mord	Mord
			DH				
dh(o)igh	teichos	fi(n)gere	deigan	dah	dough	teic(g)	Teig
dhe,- dho-	tithemi	feci, condo	taujan	don	do	tuon	thun
dhur-	thura	foris (pl.)	daurons(pl.)	duru	door	turi (pl.)	thür
	eruthros	ruber	rauths	read	red	rot	rot
udhr	outhar	uber		uder	udder	utar	Euter
medhyos	més(s)os	medius	midjis	midd	mid	mitte	Mitte
wrdho-		verbum	waurd	word	word	wort	Wort
widhewa	aitheos	vidua	widuwo	widuwe	widow	wituwa	Wittwe
			B				
	turba	turba	thaurp	thorp	thorp	dorf	Dorf
		labi	slepan	slaepan	sleep	slafan	Schlaf
	hupnos	somnus					
			P				
patér	pater	pater	fadar(rare)	faeder	father	fater	Vater
per,- por-	poros	peritus	faran	faran	fare	faran	fahren
porkos	(porkos)	porcus	*farha-	fearh	farrow	farah	Ferkel
pu	puon	pus	fuls	ful	foul	ful	foul
pel	pélla	pellis	fill	fell	fell(=hide)	fell	fell
ped-	péda	pedica		feter	fetters	fezzil	Fessel
plu-	pleuso (fut.)	pluo	fl(i)utan	fleotan	fleet	fliozzan	fliessen
	polos	pullus	fula	fola	foal	folo	Fohlen
penqe	pénte	quinque	fimf	fif	five	funf	fünf
peku		pecus	faihu	feoh	fee	fihu	Vieh
	skapto		skaban(b=v)	sceafan	shave	scaben	schaben
	hupér	super	ufar	ofar	over	ubir	über
apo	apo	ab	af	of	of, off	aba	ab
			BH				
bhéro	phéro	fero	gubairan	beran	bear	giberan	gebären
bheu	phuo	fui, fio		beo	be	bin	bin
bhrator	phrator	frater	brothar	brothor	brother	bruodar	Bruder
	phagos	fagus	*boka	boc, bece	beech	buohha	Buche
bhrewa	ophrus			bru	brow	brawa	Braue
bhru		findere	beitan	bitan	bite	bizzan	beissen
	phlegein	flagrare	*blikan	blaec	black	blecchassen	Blitz
		flos	bloma	blostm blom	bloom blossom	bluoma	Blum
phami	phaton	fari		bann	ban	ban (n)	Bann
		fiber	*bibrus	beofor	beaver	bibar	Biber
	grapho		*kairfan	ceorfan	carve		kerben
glubh-	glupho	glubo	*kl(i)uban	cleofan	cleave	chlioban	klieben
l(e)ubh-		lubet	liufs	leof	lief	liob	lieb
			G				
gno,- gen-	gignosko	nosco	kunnan	cnawan cunnian	know can	chunnan	können
	génos	genus	kuni	cynn	kin	chunni	Kind
	gonu	genu	kniu	cneo	knee	chniu	Knie
	geuo	gustus	kiusan	ceosan	choose	chiosan	kiesen
	amélgo	mulgere	*milkan	melcan	milk	melchan	melken
wrg, werg,	e(i)rgo	urgeo	wrikan	wrecan	wreak	rehhan	rächen
ego	ego	ego	ik	ic	I	ih	ich
		frangere	brikan	brecan	break	brehhan	brechen
	stig-ma	instigare		sticca	stick	steccho	Stecken
			K				
crntom	hekaton	centum	hund	hundret	hundred	hundert	Hundert
kr, ker	kéras	cornu	haurn	horn	horn	horn	Horn
krd-	kardia	cordem	hairto	heorte	heart	herza	Herz

Aryan	Greek	Latin	Gothic	A. S.	Eng.	O. H. G.	German
	kuon	canis	hunds	hund	hound	hunt	Hund
		caput	haubith	heafod	head	houbit	Haupt
	kratus		hardus	heard	hard	hart	hart
	klutos	inclutus	*hluda	hlud	loud	lut	laut
		capio	hafjan	hebban	heave	hebban	heben
	klino	inclinare		hlinian	lean		
octo	okto	octo	ahtau	eahta	eight	ahto	acht
	orektos	rectus	raihts	reoht	right	reht	recht
	keimai	civis		hyf	hive		
				GH			
	chortos	hortus	garda	geard	yard	garto	Garten
ghans-	chan	(h)anser	*gans	gos	goose	gans	Gans
	cholos	fel	*gallo	gealla	gall	galla	Galle
ghel-	chloa	helvus		geolo	yellow	gelo	Gelb
	chaino	hiare		ganian	yawn		
ghyes-	chés	hesternus	gistradagis	gistrandaeg	yesterday	gesteron	gestern
wegh-	ochos	veho	gawigan	waegen	wain	wegan	wegen
				GW			
	geranos	grus		cran	crane	cranuh	Kranich
	genus	gena	kinnus	cin	chin	chinni	Kinn
	guna		qino	cwén	queen		
		gelu	kalds	c(e)ald	cold	kalt	kalt
jugwom	zugon	jugum	juk	geoc	yoke	joh	Joch
		augeo	aukan	eacan	eke	ouhhon	auch
teg- tog-	tégos	tegere, toga	*thak	thaec	thatch	dah	Dach
gwios	bios	vivus	qius	cwicu	quick	chec	keck
gwem-	baino	venio	qiman	cuman	come	cheuman	kommen
				Q			
q(e)rt	kurtia	crates	haurds	*hyrd	hurdle	hurt(di)	Hurde
qreu-	kréas	cruor	*hrawa	hrea	raw	ro	roh
	karpos	carpo		haerfest	harvest	herbist	Herbst
	kolonos	collis	hallus	hyll	hill		
	ogkos	ancus	kals-agga	angul	angle	angul	Angel
	leukos	lucere	liuhath	léoht	light	lioht	licht
	kaleo	calare		*gehalian	hale	holon	holen
	akouo	(cavere?)	hausjan	heran	hear	horen	hören
	kalamos	calamus		healm	halm	halm	Halm
qo,- qe-	pote	quod	hvas	hwaet	what	waz	was
seq-	hépomai	sequor	saihwan	seon	see	sehan	sehen
penqe	pénte	quinque	fimf	fif	five	funf	fünf
penqtos	pémptos	quintis	fimfta	fifta	fifth	fimfto	fünfte
qetuer-	tétteres	quattuor	fidwor	feower	four	fior	vier
wlqo-	lukos	(lupus)	wulfs	wulf	wolf	wolf	Wolf
				GHW			
ghwostis		hostis	gasts	gest	guest	gast	Gast
stighw	steicho	vestigium	steigan	stigan	style	stigan	steigan
	léchos	(lectus)	ligan	licgan	lie	ligan	liegen
ghever-	thermos	formus	*warms	warm	warm	warm	warm
	onuchos (gen.)	unguis	*nagls	naegel	nail	nagal	Nagel

There is one class of words which Grimm's law does not explain. For instance, why Greek kratús, A. S. heard, English hard, German hart. To cover such exceptions, Karl Verner, in 1875, formulated a law which may be roughly stated as follows:

The Aryan surds (or tenues, t, p, k, s,) if they do not follow the accent undergo a second shifting in Teutonic, i e., to d, b, g, r.

Examine the following examples:

Aryan	Greek	Latin	Gothic	A. S.	Eng.	O. H. G.	German
	kratus		hardus	heard	hard	hart	hart
	pater	pater	fader	faeder	father	fater	Vater
	klutos	inclutus	*hluda	hlud	loud	lut	laut
		A. S. risan, >	*rasjan, >	raeran	rear		

THE VOWELS

The most striking changes in the vowels are in the history of Anglo-Saxon a (long), ea (long), and o (long).

A (long).

A. S.	Eng.	Ger.	O. H. G.	Goth.	Teut.	Lat.	Gek.	I. E.
a	o	ei, e(h)	ei, e	ai	ai	{ ae	ai	ai
						{ oi, oe, u	oi	oi
an	one	ein	ein	ains	ainos	unus, oinos, oenos	oinos	oinos
wat	wot	weiss	weiz	vait	waite	vidit	oide laios	woid-
slaw	slow		sléo (dull)		slaiw-	(s)laevos	(slaiwos) aion	slaiwos
awo	(cf. aye)	ewig	ewig	aivs	aiw-	aevom	(ϑiwon)	aiw

A. S. a had at first its true Latin value, was later narrowed and rounded until it had approximately the sound of au in aught (cf. the slurred pronunciation of children in paw and maw for pa and ma. Sweet says this particular narrowing is a climatic effect and noticeable in all northern climes.) When the Norman French came and rewrote Anglo-Saxon they used their o to represent this ou sound. Since then the rounding has continued until we now have our o representing an original A. S. a. . . . In about a dozen words the au sound has been retained;—cf. wroth, cloth, aught, thaw, naught, or, nor, ought. . . . In about the same number the vowel has become still shorter:—holiday, sorrow, not, gone. . . . In three or four the shifting to o took place so early that the second shifting of o to oo (see below) occurred:—who, two, whom, hood.

Note the English form and the German cognate for each of the following A. S. words in a: twa, hal, halig, (ge)dal, ath, lath, lathian, clath, bathie, has, gast, draf, an, nan, scan, stan, ban, ham, ac, stracian, tacen, agen, dag, hat, smat, wrat, had, rad, strad, brad, rap, sape. . . Also for each of the following: ra, sta, wa, gan, ta, har, lar, sar, mare.

A comparison of such Eng. and Ger. forms with their cognates in the several Teut. dialects, proves that the Tuet. original of A. S. a, Ger. ei, e(h), was a diphthong, ai, pronounced as Eng. i in wine. Notice that Ger. ei has the same sound, that A. S. a is simply the first element of the diphthong, and that Gothic retains both the original sound and character. Cf. Gothic, twai, hails, wai, dails, ains, aiths, stains.

Philologists have determined that the Aryan original of Teut. ai was sometimes ai and sometimes oi. In other words Aryan ai and oi fell together as ai in Teutonic. . . . In the oldest Latin inscription oi is frequently found as the representative of Aryan ai. In later Latin this gives place to ae and, in originally unaccented syllables to i. Cf. *magnai rei publicai gratia* (Plautus). Cf. caedo and incido. . . . Aryan ai became Greek ai. . . . Give Greek cognates for aedes,

prae, aevum. . . . Compare case suffixes of Dec. I in Latin with those of Dec. I in Greek. . . . Aryan oi in syllables having the chief accent became in Latin oe, u, and i (?). Cf. oinos, oenos, unos. Cf. moenia and munia. Cf. Lat. vinum and Greek oinos, Lat. vicus and Greek oikos. In unaccented syllables Latin i occurs. Cf. Greek hippois and Lat. equis. . . . Aryan oi became Greek oi. . . . Cf. case endings of Dec. II in Lat. with those of Dec. II in Greek. . . . Cf. fidus and pe-poith-a, is(ti) and toi. . . . Cf. English drove, A. S. draf, O. H. G. *treib*, Goth. *draib* and such parallel post-formations with the Greek root *loip* in *leloipa*. . . Cf. Greek altho, Latin aedes, O. H. G. eit, A. S. ad; Greek nai, Latin nae, ne, A. S. na, Eng, no; Greek parai, Latin prae; Latin caedo? O. H. G. sceidan, G. scheiden, A. S. sc(e)adan; Greek leloipa, Goth. laihv, O. H. G. leh -lihan), A. S. lah, cf. Eng. loan, A. S. lah fr. leon=lihon) (cf. Gk. leipo.

EA (long)

A. S.	Eng.	Ger.	O. H. G.	Goth.	Teut.	Lat.	Grk.	I. E.
eac(conj.)	eke	auch	ouh	auk	auk—	aug-eo	augsano	aug
eare	ear	Ohr	ora	auso	aus—	auris	ous	ous
read	red	roth	rot	rauths	rauda	ruber / rufus	eruthros	roudho / rudh

Thus just as I. E. oi and ai fell together in Teut. ai, so I. E. ou and au became Teut. and Goth. au, O. H. G. ou, and o (before dental consonants and h), G. au and o, A. S. ea. . . . A. S. ea (pronounced as a diphthong, each letter having its Lat. value) followed the fortunes, in its development, of its first component (*e*, e) and usually has now in English the pronunciation of e (we) or of e (men). The spelling ea is usually retained, but we may have simply e or even ee. A following ev may modify the vowel sound. A very few words have developed as though from A. S. a (the latter element of the original diphthong).

Note the Eng. form and the German cognate for each of the following A. S. words in ea: heawan, sceawian, heafod, deaw, bereafian, geleafa, sceaf, deaf, seam, dream, beam, leac, cage, heap, hleapan, ceap. . . . Also for the following: fleah, death, leas, ceas, east, hreaw, streaw, bean, stream, heah, theah, threatian, great, dead, bread.

O (long)

	A. S.	Eng.	Ger.	O. H. G.	Goth.	Teut.	Lat.	Grk.	I. E.
(A)	brothor	brother	Bruder	bruodar	brothar	brothar	frater	phrater	bhrator
	modor	mother	Mutter	moutar		modar	mater	mater	mater
(B.)	fot	foot	Fuss	fuoz	fotus	fot	(ped-)	po(d)s	pod- / ped-
	bloma	bloom	Blume	bluoma	bloma	blom-	flos		bhlo-
(C.)	mona	moon	Mond	mano	mena	meno	men-sis	men	men-
(D.)	gos	goose	Gans	gans		gans	(h)anser	chan	ghans-
	toth	tooth	Zahn	zand	tunthus	tanth / tunth	dent-	odont-	dont / dnt

The Anglo-Saxon o (long) retained its Latin value, but in the M. E. period there was developed after it a oo sound which finally absorbed the preceding o (long). The spelling is usually oo in English, but some words retain the original o (long) either in spelling, or sound, or in both (especially before w). . . . If the vowel is shortened the spelling may be oo, o, u. . . . A few words shifted from

o long to oo (u) early enough to undergo a second shifting of u (short) to ou (cf. A. S. u below).

Note the English form and the German cognate for the following A. S. words in o (long): (A. and B.) sco, to, do, swor, flor, stol, scol (Lat.), col, pol (Lat.), rothor, both, brothor, bosm, moste, blostm, rowan, growan, glowan, blowan, hof, hof, gedon, loma, -dom, boc, broc, sohte, slog, genog, drog, ploh, bog (boh), fot, hod, rod, stod, flod, mod, god, brod, blod. (Notice that in a few instances the German vowel has the umlant, i. e.—has suffered i-mutation.)

The Gothic forms show a long o: brothar, stols, fotus, bloma, boks, flodus, blotha, for, skohs, gods. . . . The original Teutonic vowel was o (long). In other words o (long) and a (long) fell together in Tuet.

Note that under (D) the Anglo-Saxon drops the Aryan nasal and lengthens the vowel in compensation.

THE DERIVATION OF ENGLISH FROM LATIN.

About two-thirds of our vocabulary comes from Latin. Part have come from the Popular Latin brought by the Roman soldiers into Gaul, through Popular French into English. These words present the chief difficulties. If they are understood the derivation of the words that have come from Classical Latin direct into English, or through Classical French, which took them direct from Learned Latin, present no problem.

Old French came from the Popular Latin brought by the Roman soldiers into Gaul. There were differences between Popular and Literary Latin.

1. In Vocabulary, while there were Greek words in Learned speech, there were "Homespun" words in Popular:

Lit. Lat.	Pop. Lat.	Old Pop. French	English
equus	caballum acus.	cheval	chivalry
pugna	bataliam accus.	bataille	battle
iter	viaticum accus.	voyage	voyage
urbs	villam accus.	ville	vill-age

2. In Grammar, Popular Latin by the fifth century had dropped all cases but the nominative and accusative.

3. In Pronunciation,

   1. Syllables: Popular Latin had dropped most short uninitial vowels immediately preceding the accent, especially between l, r, and p, d; s and t; m and n; and mutes and liquids.
   2. Vowels:

Lit. L. a, a	ae, e (short),	ae e, i (short)	i	e	o, u	u	au, aou
Pop. L. a	e "	e	i	o	o,	u	au (aught)

   3. Consonants:—H and final m were dropped. Di became j.
   4. Accent:—"Common" penults were accented.

This brings us to the great laws of Popular French philology.

1. Old French kept the Latin accent and accented vowel.

The vowel might be modified or combined with another, but it was

not dropped. But the consonant of the accent syllable, unless initial, was not necessarily retained.

2. It kept the first syllable, that is, the initial consonant or first vowel or both. Subject of course, to regular modifications.

3. It started with the consonant and vowel changes begun in popular Latin.

4. It completed eliding the unaccented vowels immediately before and after the accent. But a after accent became e, but half pronounced when final. If the eliding of a vowel brought three consonants together, the middle one was oftenest dropped.

5. Sometimes instead of dropping a vowel, the consonant between two vowels was dropped and the vowels combined.

6. The most striking vowel and consonant changes were as follows:

Long or short a became e; e (short) or ae became ie; o (long), o (short), u (short), became ou, eu: ae, oe, e (long), and i (short) became oi; all if accented and at the end of a syllable.

T and d were dropped between vowels and were usually dropped or assimilated before a consonant; b, v, and p became v between vowels and were usually dropped or assimilated before a consonant, and became f when final; c before a became ch; g before a became j; both became soft before e and i, but intervocalic g was assimilated before them and became i. Both became i before a consonant. Such an i combined with the preceding vowel. A nasal developed such an i except after o and u.

Examples of the dropping of unaccented vowels and intervocalic consonants are the following:

Verbs That Drop an Unaccented Vowel (I Conjugation).

(Note the original meanings.)

English	Mid. Eng.	French	Latin	Latin Der.
acquaint	acqueynten acointen	acointer	adcognitare	ad and cognitare—(g) noscere
acquit	aquiten	acquiter	acquietare	ad and quietare—quiqnus
bound		bondier	bombitare	bombus—Greek
chafe	chaufen	chaufer	caleficare	calere and facere
commence		commencer	cum and initiare	initium—in and ire
couch	couchen	coucher, colcher O.	collocare	cum and locare—locus
count		conter, compter	computare	cum and putare
daunt	danten	danter, donter	domitare	domare
despatch		despe(s)cher	dispedicare L. L.	dis and pedica—pes, pedis
meddle	medlen	medler, mesler	misculare	miscere
preach	prechen	pre(s)cher	praedicare	prae and dicare—dicere
sever		sevrer	separare	

Verbs That Drop an Intervocalic Consonant (First Conjugation).

English	Mid. Eng.	French	Latin	Latin Der.
chasten, chastise	.	chastier	castigare	castus (pure)
covet	coveiten	coveiter O.	cupiditare	cupidus—cupere
cry	crien	crier	quiritare	queri
deny	denien	denier, deneier O.	denegare	de and negare

CHRONOLOGICAL INDEX

RELIGION	PHILOSOPHY	SOCIAL SCIENCES INCLUDING ECONOMICS, POLITICAL SCIENCE, INSTITUTIONS, LAWS, EDUCATION, ETC.	NATURAL SCIENCES
	ERA OF ASSYRIA—BABYLONIA. 4000 B. C.		
Babylonian Account of Creation, I, 9. The Chaldean Flood Story, I, 16. Legend of Sargon, 3800 B. C., I, 21. Ishtar's Descent into Hades, I, 22. Penitential Psalms, I, 25.		Invented cuneiform writing on clay tablets.	Named the 12 signs of the zodiac. Discovered the cycle of 223 lunar months in which eclipses recur in regular order.
		Babylonian Laws, I, 27.	Knew about squares and cubes of numbers from 1-60.
		Recent archæological discoveries in Babylonian society in vol. X.	Built in brick.
	ERA OF EGYPT. 3000 B. C.		
Worship of Osiris in Book of the Dead, I, 29, illustrating the Egyptian belief in the life after death, the intense materiality of that life, the power of assuming various forms, the judgment of the dead, rules of life, etc.		Invented heiroglyphic writing.	Mensuration and art of building shown in the pyramids.
Hymn to the Nile, I, 79.		Egyptian life described by Herodotus (400 B. C.), I, 80-108.	Marked the length of the year.

Religion	Philosophy	Social Sciences	Natural Sciences
	ERA OF THE JEWS.		
See Genesis, the Psalms, and the Prophets.	See Proverbs, Job, Ecclesiastes, Book of Jesus, Son of Sirach.	See Exodus, Leviticus, Numbers, Deuteronomy.	
	ERA OF THE BRAHMANS.		
Vedic Hymns, showing the early personification and worship of the forces of nature: To the Unknown God, I, 109. To Vata (The Wind), I, 110. To Agni (Fire), and the Maruts (Storm Gods), I, 110. To the Maruts, I, 111. To the Maruts, I, 112. To Rudra (Lightning), I, 113. To Vayu (The Wind), I, 114. To Agni and the Maruts, I, 114. To Rudra, I, 115.			
The Upanishads, showing the later philosophical development of the religion. The Brahmans gradually reduced the many gods of nature to one, and identified that one in nature with the self of the individual. This knowledge was made essential to salvation and jealously guarded by the caste. Katha Upanishad, the secret disclosed by Death to Nakiketas, I, 116-126.	The idea of the identity of the universe with the self, I, 126, 154-160, 185, 194, 217, etc. See the Upanishads throughout.	Laws and life of the castes, I, 201-208. Education, I, 127—, 162—, 185—.	

Religion	Philosophy	Social Sciences	Natural Sciences
Brihadaranyaka Upanishad, the gradual unfolding of the Brahman belief by Yagnavalkya, I, 127-161. Khandogya Upanishad, other unfoldings of the secret, etc., I, 162-195. The Creation, I, 195. The Ages, I, 200. Transmigration of souls and rewards and punishments, I, 208-217.			
	ERA OF PERSIA.		
Zoroaster (somewhere between the fifteenth and tenth century B. C.) The Gathas—the Good and Evil Principles, I, 354-381.			
	ERA OF CHINA.		
Confucius (551-478 B. C.), I, 382-411. More ethical than religious.	Rules of life, I, 382-411.	Many of the customs and rules of propriety of China to-day date back to Confucius, I, 382-411.	
	ERA OF BUDDHA.		
Buddha (Fifth century B. C.), objected to the caste system of the Brahmans, and made a better life hereafter depend	All of Buddha's sermons are ethical in their nature. The "eight-fold path," I, 220.	Rules of conduct, I, 233-245. Customs of Buddha, I, 253-322. Proverbs, I, 323-353.	

Religion	Philosophy	Social Sciences	Natural Sciences
on right conduct and purposes rather than merely on knowledge. He still retained the Brahman idea of an impersonal God (Brahma) and the transmigration of souls. Foundation of the Kingdom of Righteousness, containing the "eight-fold path," I, 220-224. On Knowledge of the Vedas, against the Brahmans, I, 225-245. All the Asavas, the ideas that should be cherished or abandoned, the rules of conduct, against the soul, etc., I, 245-253. The Last Days of Buddha, the Life of Buddha, the Buddhist Gospel, I, 253-321. Dhammapada, the choicest Buddhist thoughts and sayings, I, 322-353.			

Religion	Philosophy	Social Sciences	Natural Sciences
	ERA OF GREECE.		
Hesiod, II, 3-34. The Creation, II, 4. Genesis of the Gods, II, 6-26. Conquest of Uranus by Cronos, II, 7. Conquest of Cronos by Zeus, II, 13.	The first step in Greek philosophy was made by asking what is the permanent, unchanging reality behind the shifting changes of nature. The early philosophers touch on many things, but this question runs through them all. Thales (about 585 B. C., thought this	Life and institutions of the Spartans, II, 105-135. Spartan education. Life and institutions of the Athenians, II, 54-105. Draco (621 B. C.), II, 56. Solon (594 B. C.), II, 57-63. Laws.	The Greeks made many brilliant scientific *guesses*, but without *proof*, the true could not be told from the false. Thales knew something about mensuration. Foretold eclipses

Religion	Philosophy	Social Sciences	Natural Sciences
The theft of fire for man by Prometheus, II, 15, 27. Woman (Pandora) and the entrance of evil, II, 16, 27.	source of all things to be *water*, II, 138-140.	Sociological poems — extant parts.	by means of the Babylonian cycle of 223 lunar months. Marked solstices and equinoxes.
Subjection of the Titans, II, 17. The Four Ages, II, 28. Rules of life, II, 32. Ideas of the Future Life.	Anaximander (610 B. C.—after 546 B. C.) thought there was an *infinite but indeterminate substance* back of things which produced things by separating into its opposites. He thought man came from other animals in the beginning, arguing from the length and helplessness of human infancy, II, 140-143.	Peisistratus (560 B. C.), II, 63-67.	Anaximander thought the heavenly bodies wheels of fire. Rain moisture drawn up by the sun. Living creatures first came to exist in the sea. Man evolved from lower animals, shown by the weakness and length of his infancy. The earth cylindrical. II, 140-143. Made map of the world and sun-dials.
Descent of Odysseus into Hades, and his description of Hades, II, 35-49. Elysium, II, 49-52. The mysteries, II, 52.	Anaximenes (latter half of 6th century B. C.) thought the world substance to be *infinite*, but *air*, II, 143-145.		Anaximenes thought all things came from air.
Pythagoras founded a religious order that for a time held the political power in Croton.	Pythagoras (about 570 B. C. ?). Most of the legends about Pythagoras are mythical; the sayings that seem most surely to go back to him are like the taboos of a "medicine man," II, 145, 146.		
Greek anthropomorphism satirized by Xenophanes.	Xenophanes (about 571 B. C.—after 479 B. C.) believed the universe to be *one unchangeable God*, and satirized the Greek idea of many human-like gods,	Hippias and Hipparchus (527-510 B. C.), II, 67-69.	

Religion	Philosophy	Social Sciences	Natural Sciences
	II, 146-148. All things from earth and water.	Cleisthenes (508 B. C.), II, 69-72.	
	Herakleitos (around 500 B. C.), thought the characteristic of the world-substance to be *a continual flux* from opposite to opposite, and *the source of all things to be fire*, II, 148-156.		
	Parmenides 515 B. C.—440 B. C. ?) believed the universe to be without beginning or end in time, immovable and unchangeable. Hence in his developing the idea of the unity of the universe to its limit, he denied any real change at all, II, 156-160.		
Transmigration of souls believed in by Empedokles.	Empedokles (first half of 5th century B. C.) tried to combine these theories. He sought to find in water, air, fire, and earth, the four elements of things, with love and hate as the causes of motion, II, 160-175.		Empedokles: the structure of the pores, II, 168. The senses, II, 174. Trees the first living things, II, 178.
	Anaxagoras (1st half of 5th century B. C.) thought there are as many elements as there are qualities, with Mind ruling all the mixture, II, 175-180.		Anaxagoras thought the earth flat, the sun a stone the size of the Peloponnesus. The moon gets her light from the sun. Planets move. Cause of eclipses, the intervention of the earth or moon.

Religion	Philosophy	Social Sciences	Natural Sciences
	Zeno (489 B. C.— ?) reinforced the idea of the unity of the universe held by Parmenides, by showing the difficulties involved in the idea of many elements and plurality, II, 180-182.		
	Melissos, the general of Samnos, victor over the Athenian fleet in 440 B. C., argued for the unreality of our perceptions and the paradoxical unity of all things, II, 182-185.		
	The Pythagoreans thought the constant number relations were the true reality of the universe, II, 185.		The Pythagoreans thought the earth round and to go around the sun.
Protagoras was banished for doubting the existence of the Gods.	Protagoras (480 B. C.— ?) thought all knowledge is merely a question of personal opinion, and hence true science impossible, II, 186, 201—.	Pericles (460-429 B. C.), II, 75—.	
	Leukippos and Demokritos (460 ? B. C.—360 ? B. C.) developed the idea of the atom and of the universe being developed from the accidental rushing together of purposeless atoms, II, 187.		Leukippos and Demokritos. The atomic theory, II, 187.
Socrates was executed for introducing strange gods. On immortality, II, 249-311.	Socrates (470 B. C.—399 B. C.) began, with the Sophists, to turn philosophy to the discussion of life and happiness. He believed that happiness would be brought by virtue, virtue secured by knowledge, and that things may be		

RELIGION	PHILOSOPHY	SOCIAL SCIENCES	NATURAL SCIENCES
	grouped into classes and defined, and a general statement made of the class that will hold good. Hence the goal of science would be classification and definition, II, 187, 191-239.		
Plato. The Phaido, II, 249-311.	Plato (429 B. C.—348 B. C.). The possibility of science, II, 191-239. The doctrine of Ideas, II, 239-249. The Ideas as final causes, and the question of immortality, II, 249-311. The philosophy of the state, II, 311-338. Diogenes the Cynic (412 B. C.—323 ? B. C.) believed the greatest good to be freedom from wants; hence he rebelled against all civilization, II, 339-348.	Plato began political science. Origin of the State, II, 311-320. Education by the State, II, 320-328. Community in the State, II, 328-338.	Hippocrates (420- ?), III, 286-288. Showed that diseases come not from the anger of the gods, as formerly thought, but from natural causes. Eudoxus (406- ?). studied the movements and return of the planets, III, 288.
Aristotle. Proof of God's existence, II, 352-363. Basis of Ethics, II, 364, 382.	Aristotle (384-322 B. C.). The relation of the general to the particular (logic), II, 350. The interrelations of things (the categories), II, 345-350. The examination into existence, culminating in the proof of God, II, 352-363. The basis of ethics; happiness, the greatest good, is the result of the activity of the soul in accordance with its greatest excellence; virtues, habits; the law of the middle path, II, 364-382.	Aristotle. Origin of the State, II, 383-386. The Ideal State, II, 386-418. Education in the State, II, 411-418. History and description of the Athenian constitution, II, 54-105.	Aristotle. Made great zoological collections.

Religion	Philosophy	Social Sciences	Natural Sciences
	Philosophy of the state, II, 383-418. Developed Rhetoric. Zeno the Stoic (350 ? B. C.—258 ? B. C.) thought the chief good to be a virtue that by calm submission to natural law, by doing one's duty, rose superior to pleasure, trouble, desire, or fear, II, 418-425. Epicurus (341 ? B. C.—270 B. C.). The chief good the highest form of pleasure, II, 426-430.		

ERA OF ROME.

Religion	Philosophy	Social Sciences	Natural Sciences
The Roman religion was closely related to the Greek, and was later identified by the Romans with the Greek. As in the case of the Brahmans and Greeks, their gods originally represented natural forces. They developed but few myths about them, but later adopted the Greek. Peculiar Roman religious institutions were the household gods called the *lares*, the judging the wills of the gods through auspices, etc.		Appian's review of the Roman contentions, III, 5. Origin of Roman law, III, 9.—Justinian's Digest. The Quaestor (before 509 B. C.), III, 52. The right of appeal to the people in capital cases, 509 B. C., III, 12.—Cicero. The Tribunes, 494 B. C., III, 3, 30. The Decemvirs, 451-449 B. C., III, 13—, 15—. Fragments of the Twelve Tables, 449 B. C., III, 9—. Laws passed by the people assembled in tribes to be binding on all, 449 B. C.—Dionysius Halicarnassus, III.	

Religion	Philosophy	Social Sciences	Natural Sciences
		Renewal of the sacredness of the Tribunes, 449 B. C., III, 16. Right of intermarriage—the Canuleian Law—B. C. 445, III, 17-25. The Military Tribunes, 444 B. C., III, 24. The Censors established, 443 B. C., III, 34. A regular army established, the troops paid, and winter campaigns begun, 406-400 B. C., III, 25-30.	
		The Praetorship, 367 B. C., III, 46. The Licinian Law, 361 B. C., compromising the land question; one consul a pleb; interest deducted from the principal of debts; slave labor, and amount of land held limited, III, 35-46. All offices thrown open to the plebeians by the Publilian laws, 336 B. C. Orders of commons binding on all. III, 47.	
		The censorship, 312 B. C.; also public road building by Appius Claudius. Priesthood opened to plebeians, 300 B. C., III., 48. Hortensian Law, 287 B. C., made all laws passed by the plebs alone binding on all. III, 53.—Aulus Gellius. Annexation of Sabine territory, 290 B. C. War with Pyrrhus and Tarentum. All Italy made part of the growing empire, 272 B. C.	Appian road, 312 B. C., the beginning of public road building, etc. Graeco-Roman Science. Aristarchus (3rd century B. C.) held the Copernican theory that the earth revolves on its own axis and about the sun, III, 288.

Religion	Philosophy	Social Sciences	Natural Sciences
		First Punic War, 264-241 B. C.	Euclid (300 B. C. ?) founded geometry, III, 288.
		Second Punic War, 218-201 B. C. Spain acquired.	Archimedes (287-212 B. C.), discovered the principle of the lever, specific gravity, the water-screw, etc., thus founding mechanics, III, 288-290.
		Second Macedonian War, 200-196 B. C. Greece "liberated."	
		The Bacchanalian revelers repressed, 186 B. C., III, 65-77.	
		Third Macedonian War. 172-168 B. C.: Macedonia divided.	
		Destruction of Carthage, 146 B. C.	Erastosthenes (276- ? B. C.) measured the circumference of the earth, III, 290.
		Destruction of Corinth, 146 B. C.	
		Strictures on dress and food, 145 B. C., III, 54-65.	Hipparchus (160- ? B. C.) catalogued the stars, III, 290. Noted the precession of the equinoxes.
		The Gracchi, 133-121 B. C., III, 77-90.	
		Mismanagement of the provinces, III, 77-90.	
		Rome after the Punic Wars, by Polybius. An analysis of the Roman government, military institutions, etc., III, 166-193. Rome and Carthage compared.	
		Transalpine Gaul made a province, 120 B. C.	
		The Social War, 90-89 B. C. Allies admitted to citizenship, III, 90, 91.	
		Marius and Sulla, 88-79 B. C.	
Cicero on immortality, III, 233-262.	Cicero. Scipio's Dream, III, 233-241.	Cicero (105-43 B. C.), III, 215-262. The Principles of Law, III, 216-228. The Best Forms of Government, III, 228-233.	

Religion	Philosophy	Social Sciences	Natural Sciences
	The Contempt of Death, III, 241-262.	The First Triumvirate, 60 B. C. Civil War between Caesar and Pompey, 49 B. C. The Second Triumvirate, 43 B. C.	Lucretius (98-55 B. C.), the atomic theory, III, 262-275.
Lucretius on immortality, III, 275-285.	Lucretius. The atomic theory.	Growth of luxury at the close of the republic, III, 193.—Lucan. The empire established under the guise of a republic, 27 B. C., III, 92.—Dio Cassius. Elections taken from the people and given to the senate, 14 A. D., III, 92.	
Philo-Judaeus. Mysticism.	Philo Judaeus (20 B. C. —40 A. D.). Neo-Platonism. The Creation of the World. Pre-Christian Ascetics, III, 355-369.	Luxury increased from the time of Actium (31 B. C.) to Tiberius; then began to decline among the senators though the extravagance of the emperors increased through the time of Nero (54 A. D.); and with Vespasian a period of parsimonious living began, lasting about 100 years. III, 194—.	Pliny the Elder (23-79 A. D.). The Scientific Ideas of the Time, III, 294. The Inventors of Various Things, III, 305-310.
Seneca. Stoicism. Persecution of the Christians under Nero, 64 A. D., IV, 6.	Seneca (4 B. C.—65 A. D.) The Stoic philosophy of Peace of Mind, III, 328-354.		
		Growth of royal power under Vespasian, 69 A. D., III, 93. Quintilian (35-95 A. D.), The Ideal Education, III, 312-326.	

Religion	Philosophy	Social Sciences	Natural Sciences
		Nerva, care of indigent children 96-97 A. D. III, 94.	
Pliny, Trajan and Hadrian on the Christians, IV, 7.	Epictetus (? -117 A. D.) Stoic, Philosopher. Discourses, III, 392-407.	Trajan, 98 A. D. The empire at its widest extent. The paternalism of the empire, IV, 7. Plutarch (50 A. D.-120 A. D.). The training of children III, 370-391.	Ptolemy (70-150 A. D.) Theory of the heavens, III, 290.
Persecution under Marcus Aurelius, A. D. 177. IV, 9.	Aurelius. "Thoughts"—the Stoic Philosophy, III, 406	Marcus Aurelius, 161 A. D., IV, 9.	Galen (131 A. D.—?) vastly increased the knowledge of the body, III, 291. Distinguished and studied veins and arteries, VI, 9.
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Persecution of Diocletian, IV, 14. Edict of Toleration by Galerius, 303 A. D., IV, 17. Synod of Elvira, IV, 111. The problems of the church. Decree of Milan, 313 A. D., IV, 19. Origin of Asceticism, IV, 51-62.		Diocletian (284 A. D.). An absolute monarchy, III, 95-99.	
St. Athanasius (298-373). Exposition of the Faith, IV, 71. Nicaene Creed (325 A. D.), IV, 122.		Constantine the Great founds Constantinople (328 A. D.). Marcellinus: Fourth Century Roman Life, III, 202.	

Religion	Philosophy	Social Sciences	Natural Sciences
Athanasian Creed. Suppression of heathenism and heresy, IV, 62-71. St. Ambrose to Valentinian, IV, 62. Enactments from the Theodosian code, IV, 69. St. Augustine (354-430). God's Foreknowledge and Man's Free Will, IV, 75. Original Sin, IV, 90. Redemption, IV, 97. Faith, Hope and Love, IV, 102. Leo I, and the Petrine Theory of the Papacy, (440-461), IV, 125.		Theodosius, 378-395 A. D. The customs of the Germans by Tacitus, IV, 165. The Conquest of Britain, by Bede, 449-456 A. D., IV, 188. Overthrow of Empire, 475 A. D.	

Religion	Philosophy	Social Sciences	Natural Sciences
	MIDDLE AGES.		
Conversion of the Franks, 496 A. D., IV, 202, by Gregory of Tours. Conversion of Kent, 596 A. D., IV, 190 (by Bede). Conversion of East Angles, 627 A. D., (by Bede), IV, 194. Monasticism, IV. 128-165, by St Benedict. Customs and Rules. Victory of the Roman Church in Britain, 652 A. D., IV, 196 (by Bede). Mohammed (570-632). The Koran, IV, 241-277. About this period began the Era of the Arabs in Religion. Donation of Pippin, 756 A. D., IV, 203.		The Salic Law, the laws of the Franks, IV, 177-188. Justinian, Eastern Emperor, codifies existing Roman laws, 527-565. The Institutes of Justinian, the body of Roman law, III, 100-166. The laws of the Anglo-Saxons, of King Aethelbirht of Kent (560-616), of Hlothhaere and Eadric (673-686), of Withraed (690-725), of Alfred (871-924), Edward (901-924), with Guthrum the Dane, of Aethelstan (924- ?), Edmund and Edgar, IV, 211-240.	

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Donation of Karl the Great, 774 A. D., IV, 204.		Coronation of Karl the Great, 800 A. D., IV, 205. School of Karl the Great, IV, 206. Treaty of Verdun, 843 A. D., the divisions of modern Europe formed.	Geber (Djafer) (830 ? - ?). Alchemist; made nitric and sulphuric acid, IV, 278.
	Avicenna (Ibn Sina), (980-1037) doctor, and neo-Platonist, IV, 279. Eternity of universe and identity of universal intelligence in man. Avicebron (1028-1058), poet and neo-Platonist. The Will of God the final cause of the world, IV, 280. Averroes (1126-1198), commentator of Aristotle, IV, 281. Moses Maimonides (1135-1204) attempted to combine Jewish theology and Aristotle, IV, 281. Method of proving God's existence, IV, 282-284.	Feudalism. The disintegration of Europe left the barons each to govern his own county with but slight dependence on the higher duke or king. Forms of dependence of the serfs and freemen, IV, 300. Private jurisdictions, IV, 301. Homage and fealty, IV, 303. Mutual duties, IV, 306. Authority of the lord, IV, 307. Compurgation, IV, 308. Ordeals, IV, 309. Wagers of battle, IV, 315. The Struggle between Church and State, IV, 318.	Albategnuis (879?-?) calculated the length of year with great exactness, IV, 278. Ben Musa (900 ?-?) introduced algebra and Indian numerals; afterwards brought into Europe by Gerbert, Pope Sylvester II, IV, 278. Alhazen (1000?-?). Optics, refraction of light, used convex lenses, IV, 279.
Gregory VII., 1073-1085, IV, 320. Claims of the Pope. Declarations of the Church, simony, lay investiture, celibacy, annual confession, transubstantiation, IV, 323. Gregory VII. vs. Henry IV., IV, 323.	A Parallel between the Universe and Man, IV, 284-293. Propositions admitted, IV, 293-299.	Program of Gregory VII. (1073-1085), IV, 320. Claims of the pope. Declarations of the Church on lay investiture, celibacy, simony, annual confession, transubstantiation, IV, 321. Gregory VII. vs. Henry IV., IV, 323.	

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The Crusades, IV, 335-350. William of Tyre on Peter the Hermit. Urban II, Speech at Clermont, 1095. The Truce of God. Privileges of the Crusaders. Account of the Start.		Mediaeval Universities, IV, 350. Privileges, Frederick I., 1158 A. D. Gregory IX., for the University of Paris, 1231 A. D. Course of Study, Robert de Courcon, 1215 A. D. Life of Students.	
	St. Thomas Aquinas, 1225 ? - 1274 A. D. The philosophy of the Church. Scholasticism on the existence of God, IV, 359. Theory of knowledge, IV, 363.	Saxons and Normans, by William of Malmesbury, IV, 384. Rise of the Cities, IV, 390-397. English city customs. Typical charters. A typical guild. Norman Judicial Customs, 1166 A. D., IV, 397.	Roger Bacon (1214-1292). On Experimental Science, IV, 369.
John Wycliffe (1320 ? -1384). Conclusions, IV, 378. Wycliffe and Pope Gregory XI., IV, 380-383.		The Magna Carta, 1215 A. D., IV, 401. Uprising under Ball and Tyler, by Froissart, IV, 413. Marsilius of Padua (latter half 13th century). The beginning of the modern theory of the state, IV, 423.	
		The revival of interest in classical learning. Petrach (1304-1374).	Flavio Giopa (1300 ? - ?). Invented mariner's compass.

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		MODERN ERA.	
			Guttenburg invents printing, 1438, V, 5.
		Fall of Constantinople (1453) and diffusion of Greek knowledge in Western Europe, V, 5.	
			Columbus discovers America (1492). Journal of his first voyage, V, 7-26. Vasco a Gama rounds Africa to India (1498), V, 26-41.
		Machiavelli (1469-1527). Mediaeval and early modern political ideas. The Prince, V, 58-95.	
			Magellan rounds world (1519-1522). Account by Genoese pilot, V, 41-58. These geographical discoveries settled the question of the rotundity of the earth.
			Copernicus (1473-1543), argued that the earth goes round the sun. Though the knowledge of the time was not sufficient to *prove* this, yet the theory steadily grew. The Copernican Theory, V, 96-101.

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The Reformation, V, 102. Erasmus (1466 ? -1536), V, 103-110. Translated the New Testament. Satirized the foibles of the church and clergy. Benefice-Hunting. The Penitent Virgin.			Paracelsus (1498- ?). Alchemist, but turns alchemy to aid of health. Introduced antimony.
Martin Luther (1483-1556), V, 111-134. Ninety-five Theses, V, 112. Against Catholicism, V, 119. Justification by Faith, V, 127. The Peasant Revolt (1525), V, 134. The Twelve Articles (Demands) of the Peasants, V, 135.		Peasant Revolt in Germany, (1525), V, 134.	
John Calvin (1509-1564), V, 140. Doctrine of eternal election, V, 141-150.		Cortez: Account of the Aztec Civilization in 1520, V, 317-326.	
The whole case of the Protestants as given to the world in the Augsburg Confession (1530), V, 151-179. Loyola (1491-1556), V, 179. The Jesuit Constitution, V, 180-188. Revolt of the Protestant Netherlands, 1566-1609, V, 189.	Giordano Bruno (1550 ? - 1600). Mystic. Believed the universe a great animal. Burned at the stake in 1600 for openly teaching the Copernican system.	Mendoza: Founding of St. Augustine (1565), V, 327-341. Dutch Case in their Declaration of Independence, V, 189-198.	Vesalius (1536?-1564). VI, 5. Corrected Galenic ideas of anatomy by observation of the human skeleton itself. Held the ancient belief that arteries contain vital spirits. Baptiste Porta (1545- ?). Invents the camera obscura. Dr. Gilbert (1540-1603). Made the first few experiments on electricity. Found that certain substances attract when rubbed.

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	Francis Bacon (1561-1626). The philosophical doctrine of experiment. The Novum Organum, V, 234-289.	Montaigne (1533-1592), V, 198. On the Education of Children, V, 190-232. Jamestown founded (1607). Quebec: account by Champlain (1608), V, 342-354. Morton: Customs of the Indians in 1637, V, 360-376. The First Written Constitution, Connecticut (1638), V, 354-360. Hooker: Church Questions in New England, V, 378. The English Revolution (1628-1649), V, 391. The Petition of Right (1628), V, 393. First Writ of Ship-Money, Specimen, (1635), V, 396. Pym against Strafford (1641), V, 399. The case of parliament in the Grand Remonstrance (1641), 403-430. Ratke (1571-?): Educational rules, VI, 24. Comenius (1592-1670). Educational Ideas, VI, 25-38.	Fabricius (? - ?) discovered valves in veins. This led later to Harvey's discovery, VI, 7. Francis Bacon (1561-1626). All science based on experiment. The Novum Organum, V, 234-289. Galileo (1564-1642), V, 290-308. Laws of motion. Thermometer invented. Discovered mountains of moon, the moons of Jupiter, and the phases of Venus. For the Copernican System, V, 292-302. Condemnation by Inquisition, V, 302-306. Recantation, V, 306-307. Tycho Brahe (1546-1601). Compiled the Rudolphian Tables, V, 308. Kepler (1571-1630), V, 308-315. Planets move in elipses, V, 309. Areas swept over in equal times are equal, V, 309. Cubes of distances proportional to the squares of the times, V, 310. The Principles of Astronomy, V, 311-315. Harvey (1577-1657). The circulation of the blood discovered, VI, 5.

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	Descartes (1596-1650), VI, 41. Meditations, VI, 42-63. The new starting point for philosophy. Principle of certainty; "Cogito, ergo, sum;" dualism between matter and mind.	Jean Bodin (latter half of 16th century). Explained the ten-fold rise in prices by the importation of gold from the New World, VI, 155. The prevailing political economy was the mercantile system which strove for the balance of trade and discouraged imports.	Asellius discovers the lacteal circulation 1622. VI, 117.
		Thomas Mun (1571-1641), VI, 157-163. The mercantile theory. Other representatives of the mercantile school, VI, 155-157.	Torricelli invented the barometer (1644), VI, 117.
	Geulincx (1625-1669), VI, 38. Matter and mind run in harmony as do two clocks, because both controlled by their maker. Malebranche (1638-1715). "We see all things through God." VI, 38-39. Spinoza (1632-1677), VI, 63-78. Transformed Descartes dualism into a monism. God the only substance, all else manifestations.	Sir William Petty (1623-1687), a precursor of the new school. Value depends on labor, VI, 156.	Olaüs Rüdbeck found that the lymphatics furnished the heart with material for new blood (1649), VI, 117. Guericke invented the air-pump (1650), VI, 118. Pascal proved that it is the weight of the air that causes the rise of the mercury, (1656), VI, 118. Malpighi and Grew discovered the air cells in the lungs, the capillary cells, the cells in plants, etc., VI, 118.

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			Anthony von Leeuwenhoeck (1632-1723). VI, 119-123. Discovered the red corpuscles in the blood; the animalculae in water; the capillary circulation. Also an investigator of insects. Guericke invented first electrical machine (1676), VI, 118.
	Leibnitz (1646-1716), VI, 78-93. The Monadology: idea of the monad and pre-existing harmony.		Leibnitz invented differential calculus, VI, 79. Newton (1642-1727), VI, 123-141. Invented method of fluxions, VI, 123. The Composition of Light, VI, 124-134. The Theory of Gravitation, VI, 135-141. Applied the theory to explain the tides, etc. (1682).
	Hobbes (1588-1679), VI, 93-101. The beginning of the sensualistic psychology. All consciousness can be reduced to motion.	Hobbes (1588-1679). Social Contract Idea of Society, VII, 19-25. The supremacy of parliament in England, VII, 5. The Habeas Corpus Act (1679), VII, 8. The Bill of Rights (1689), VII, 16-16.	Roemer estimated the velocity of light to be 190,000 miles a second (1676). Proof, VI, 118, 146-148.
	John Locke (1632-1704), VI, 101-116. All ideas from sensation and reflection. No innate ideas or unconscious thought, VI, 39, 101-116. Things and the soul are taken for granted by us as a ground of our ideas. As clear an idea of spirit as of matter.	Locke (1632-1704. The Basis of Property is Labor, VI, 164-171. The Origin of Political Societies and the Right of the People to Revolt, VII, 25-35.	Huyghens (1609-1695), VI, 141-150). Discovered the rings and the sixth satellite of Saturn (1655). Invented the pendulum clock (1657). The Wave Theory of Light (1690), VI, 142-150. The beginning of chemistry, VI, 150-151. Robert Boyle (1627-1691), VI, 152-154. Law of the compressibility of gases. Stahl (1660-1734). The phlogiston theory that combustion is the driving off of a "fire-element", VI, 151.

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	Berkeley (1685-1753). Idealism, VI, 172. Principles of Human Knowledge, VI, 173-184.	Montesquieu (1689-1755), VII, 35-46. The principle of the separation of powers.	Boerhaave (1668, Dec. 31—1738), VI, 242-247. Studied the absorption by plants of substances from the soil, VI, 240, 242. Physiological conceptions, VI, 242-247.
Wesley (1703-1791), VI, 362-377. The Early Methodists (1739). General Rules. Doctrine of Justification. Voltaire (1694-1778). Struggled against intolerance in religion and government. On Toleration, VI, 377-391.		The physiocratic school of political economy, led by Gournay and Quesnay. Quesnay (1694-1774), VI, 392-399. General Maxims.	Linnaeus (1707-1778), VI, 247-261. New system in botany. The sex system in plants, VI, 248-261. Franklin (1706-1790), VI, 261-272. Electrical experiments. Positive and negative electricity, VI, 262-266. The identity of electricity and lightning. The lightning rod, VI, 266-269. (1747). The kite experiment, VI, 270-272.
	Hume (1711-1776). Scepticism, Economic ideas, VI, 185. Against the Principle of Cause and Effect, VI, 185. Against Personal Identity, VI, 189. Kant (1724-1804). The matter of knowledge	Rousseau (1712-1778). The "Contrat Social" (1762): The ruler only the instrument of the people, who are always sovereign, VII, 47-55. Stands for naturalness in education, VII, 46, IX. English Colonial System, VII, 55-165. See also American Revolution below. Clive (1725-1774), VII, 59-65.	Werner and the "Neptunist" theory in geology, VI, 313. Hutton and the "Vulcanist" theory in geology, VI, 312-334. Joseph Black (1728-1754), VI, 272-278. The discovery of "fixed air" (carbonic acid gas), 1753, VI, 272-278. Latent heat, VI, 272. James Watt (1736-1819), VI, 305-312. Applied the principle of latent heat to

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	from experience, the form from the mind. Space and time and the categories are mental forms. We can know only phenomena, not things in themselves, and only phenomena are bound by the natural laws we know. God and the Soul are things in themselves, not so bound, but free. Biography, VI, 201. Place in philosophy, VI, 40. The Prolegomena, VI, 203. Critique of Pure Reason, VI, 207-239.	Conquest of India. On His Conduct in India. American Revolution, VII, 166-245. See also English Colonial System above. James Otis and the Writs of Assistance (1761), VII, 167, 172-177. The Rights of the British Colonies (1764), VII, 177, 178.	the steam engine and invented the separate condenser. Priestley (1733-1804), VI, 278-283. The discovery of oxygen. Scheele (1742-1786), VI, 284-290. Discovery of oxygen. Cavendish (1731-1810), VI, 290-297. The composition of water. James Hargreaves, The Spinning Jenny, 1767, IX, 421.
		Samuel Adams, (1722-1803). Vindication of Boston (1764), VII, 178-9. Against the Stamp Act. Patrick Henry (1736-1799). Virginia Resolution against the Stamp Act (1765), VII, 179-184. Franklin examined on the effect of the Stamp Tax (1766), VII, 185-198. Chatham (1708-1778). Against the right to tax America (1766), VII, 65-77. Grenville (1712-1770). Answer to Chatham and against repeal of Stamp Tax (1766), VII, 70-72.	Lavoisier (1743-1794), VI, 297-305. The Permanence of Matter. The Nature of Combustion. Respiration a Combustion. Lavoisier overthrew the phlogiston theory and begun scientific chemistry. William Herschel (1738-1822), VI, 335-349. Discovery of Uranus (1781), VI, 335-337. Nebulous stars, VI, 337-347.

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		Mansfield (1705-1793). In favor of the Right to Tax America (1766), VII, 77-86. John Dickinson (1732-1808). Against the suspension of the New York Legislature and internal taxation. Letters of a Pennsylvania Farmer (1767), VII, 199-208. Edmund Burke (1729-1797). On Conciliation with America, VII, 87-117.	Discovered two of the satellites of Uranus, two more of Saturn, and binary stars revolving around a common center, VI, 335. That the whole solar system is rushing toward the constellation of Hercules, VI, 347-349.
		Thomas Paine (1737-1809). Common Sense (1776), VII, 209-229. Thomas Jefferson (1743-1826). A Summary View of the Rights of British America (1774), VII, 230-235. The passing of the Declaration and the arguments used for and against it, VII, 235-241. John Adams (1736-1826). On the Declaration of Independence, VII, 243. Adam Smith (1723-1790. The Principle of the Commercial or Mercantile system, VI, 399-427. Free Trade and the Colonies, VII, 117-165.	Laplace (1749-1827), VI, 349-358. Worked out the movements of the solar system in detail. The Nebular Hypothesis, VI, 350-358. Edmund Cartwright, The Weaving Loom, 1785, IX, 421. Lionel Lukin, The Life Boat, 1785, IX, 422. Montgolfier, Balloons, 1783, IX, 422. Galvani (1790), noted that electricity contracted the muscles of a frog's legs, VI, 358.
		Debates on the Federal Constitution, 1787, VII, 246-367. Those who attended were:	Volta (1745-1774). Invented the voltaic battery (1800), VI, 358-361.

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		Virginia: Geo. Washington, Edmund Randolph, James Madison, John Blair, Geo. Mason, Geo, Wythe, James McClurg. **Massachusetts:** Elbridge Gerry, Rufus King, Caleb Strong, Nathaniel Gorham. **Pennsylvania:** Benjamin Franklin, Robert Morris, Gouverneur Morris, James Wilson, Jared Ingersoll, Thos. Mifflin, Thos. Fitzsimons, Geo. Clymer. **New York:** Alexander Hamilton, Robert Yates, John Lansing. **Maryland:** Luther Martin, James McHenry, Daniel Carroll, Daniel of St. Thos. Jenifer, John Francis Mercer. **North Carolina:** Alexander Martin, Wm. Richardson Davie, Wm. Blount, Richard Dobbs Spaight, Hugh Williamson. **South Carolina:** John Rutledge, Chas. Cotesworth Pinckney, Chas. Pinckney, Pierce Butler.	

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		Connecticut: Roger Sherman, Oliver Ellsworth, Wm. Samuel Johnson. New Jersey: William Patterson, William Livingston, David Brearly, Jonathan Dayton. Delaware: John Dickinson, Geo. Read, Gunning Bedford, Richard Bassett, Jacob Broom. Georgia: William Few, Abraham Baldwin, William Pierce, William Houston. New Hampshire: John Langdon, Nicholas Gilman. The French Revolution. Montesquieu (1689-1755). The Separation of Powers, VII, 35-46. The Physiocrats. Quesnay (1694-1774). General Maxims, VI, 392-399. Rousseau (1712-1778). The Social Contract, VII, 47-55. Louis XVI. came to throne (1774), VII, 369. Turgot (1727-1781).	

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		Plans on accepting office, VII, 369, 390-394. Necker and Calonne, VII, 370. Arthur Young (1741-1820). The Condition of the French People, VII, 374-390. Sièyes (1748-1836). "What is the Third Estate?", VII, 394-398. States General (1789), VII, 370. National Assembly (June 17, 1789), VII, 371. Complaints of the People, VII, 398-411. Capture of the Bastile (July 14, 1789), VII, 371. Abolition of Feudal Privileges (Aug. 11), VII, 371, 411-414. Declaration of the Rights of Man, VII, 415-417. Origin of the Jacobins, VII, 428-430. Mirabeau. The Condition of Affairs (Oct. 15, 1789), VII, 417-428. Danton, Marat, and Robespierre, VII, 372-373. The Republic (Sept. 21, 1792). VII, 372. Execution of the King, Jan. 21, 1793, VII, 372. General War against Republic, VII, 373.	

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	Fichte (1762-1814). Idealism, VIII, 318. Doctrine of Knowledge, VIII, 319-330.	Benjamin Franklin. Information to Those about to Emigrate to America, VIII, 5. W. Winterbotham. Conditions in the United States, VIII, 15.	Edward Jenner (1749-1823). Theory of Small Pox Vaccination, 1798, VIII, 404-412. Bichat (1771-1802). The Doctrine of Tissues, VIII, 396-404. Count Rumford (1753-1814).
	T. B. Malthus (1766-1834). Principle of Population, VIII, 293-305.	T. B. Malthus (1766-1834). Essay on the Principle of Population (1798), VIII, 293-305. The Development of Political Ideas in the United States, 1789-1833. Alexander Hamilton, VIII, 30-96. The Powers of the Supreme Court, VIII, 31. Monetary Measures, VIII, 30. Discussion of a Protective Policy, VIII, 37-96. Ideas of State Sovereignty, VIII, 96. The Kentucky Resolutions (Jefferson), 1798, VIII, 97. The Virginia Resolutions (Madison), 1798, VIII, 103. The Kentucky Resolutions of 1799, VIII, 106.	The Nature of Heat, VIII, 435-441. Thomas Young (1773-1829). On the Interference of Light Waves, VIII, 442.

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	David Ricardo (1772-1823). Theory of Rent, VIII, 305.	David Ricardo (1772-1823). Theory of Rent, VIII, 305-316.	Lamarck (1744-1829). Evolution by "Use," VIII, 412-418.
	Schopenhauer (1788-1860), VIII, 337. Kant's thing-in-itself is natural will. The Will in Nature, VIII, 338.	Henry Clay (1777-1852). The "American Policy" of Internal Improvement, VIII, 148-160. The Compromise of 1820, VIII, 148. (See also on the Compromises of 1833 and 1850). James Monroe (1758-1831). The Monroe Doctrine, 1823, VIII, 288. John Marshall (1755-1835). The Supreme Court Superior to State Legislatures, VIII, 161.	Avogadro (1776-1865). Law of equality of molecules, VIII, 384-389. Dulong and Petit, VIII, 384. Relation of specific heat and atomic weights (1813). Stephenson, The Locomotive, 1814, IX, 424-426. Cuvier (1769-1832), VIII, 418. Believed in the Permanence of Species. The Mutual Relations of Organized Beings, VIII, 419-424.

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		Froebel (1782-1852). The Kindergarten, IX, 402-410.	Oersted. Identity of Electricity and Magnetism, IX, 5.
		Horace Mann (1796-1859). Lessons from Europe, IX, 410.	Ampere. Electrical Laws, VIII, 430.
		Political Ideas in the United States, 1833-1860, IX, 42.	Daguerre and Niepce, Photography, 1814-1839, IX, 426.
		Basil Hall (1788-1844). Slave Conditions (1828), IX, 46-62.	Joseph Henry, IX, 10. Electricity and Magnetism, IX, 11.
		Harriet Martineau (1802-1876). Morals of Slavery (1835), IX, 63-83.	Faraday. Electricity from Magnetism, IX, 17-21.
		Geo. McDuffie (1788-1851). The Rights of Slavery, IX, 83.	Charles Lyell (1797-1875). Uniformity in the past changes of the earth, IX, 214-233.
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OUR FOUR YEARS' COURSE OF STUDY IN THE ORIGINAL DOCUMENTS

OF

THE IDEAS THAT HAVE INFLUENCED CIVILIZATION

EDITOR-IN-CHIEF OLIVER J. THATCHER, PH. D.
UNIVERSITY OF CHICAGO

UNIVERSITY RESEARCH EXTENSION
AUDITORIUM BUILDING, CHICAGO

OUR FOUR YEARS' COURSE OF STUDY IN THE ORIGINAL DOCUMENTS

INTRODUCTION

The Original Documents that have been gathered together with infinite toil by one hundred and twenty-five leading scholars of the world, invaluable as they are, yet would fail to render their real service to the great body of the people unless reduced to a systematic plan of study. These Documents furnish for the first time the opportunity of studying the advancing civilization of the world from epoch to epoch by collating the investigations in all fields of the ages past, and arranging all in systematic form. But a work of such immense proportions to be rendered most serviceable as a systematic course of study on something like the Chautauqua basis requires an arrangement of the material suitable for such a purpose. By this means study-centers can be easily formed, or the plan pursued by the individual student. The following plan of a four years' course of study gives the necessary direction for daily study in original research, an opportunity which has never existed until this library of the world's thought brought these original resources to the hand of the professional and non-professional man alike. As an individual study this course can be followed with ease, but the formation of a class would necessarily increase the interest, enthusiasm, and helpfulness of the study. In this respect no such opportunity has heretofore been afforded for an investigation of the world's intellectual development. The following plan of a four-fold study facilitates a true appreciation of the ideas that have influenced civilization from the earliest to the present time both for the student and those not ordinarily engaged in intellectual work. An examination of the plan will show that the student works through the volumes each year in pursuing the particular development of the world's thought, whether Religious, Philosophical, Scientific or Political. With such a perfect analysis and every page of the student's work indicated all things are made ready to his hand, and to settle down to the business of his self-education. These pages present on a large scale the solution of the problem, What course of study to pursue for the largest intellectual returns.

Supplementary to this course of study in the volumes is our Study Club Department in the University Digest, a monthly magazine, which is devoted to the gathering up of original matter not advisable for the Library of University Research, and belonging also to later original research. This augments in an important degree many subjects outlined in the Course of Study.

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